RECORDS

OF THE

GEOLOGICAL SURVEY

OF

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ON THE BEDS CONTAINING SILICIFIED WOOD IN EASTERN PROME, BRITISH BURMAH, by WM. THEOBALD, JUNR., Esq., Geological Survey of India.

No fact relating to the geology of Pegu is better known than the abundance of silicified wood occurring in the valley of the Irawadi, but as no detailed account has hitherto been published of the beds from which this fossil wood has been derived, it is my intention in the present notice to give such a sketch of them as will show their most salient points of interest and facilitate the recognition of the group elsewhere, where its occurrence might from its mineral character be overlooked and its beds confounded with other and more recent deposits. At the same time I shall, as much as possible, restrict myself to the area of Eastern Prome and to the fossil-wood group proper, only incidentally alluding to the great series of beds with which it is intimately connected, and on which it rests, as each group has a marked facies of its own, is generally, as a rule, easily recognizable and characterised by entirely different organic remains, though the balance of evidence as yet tends to prove a passage from one to the other and an undisturbed sequence in the beds composing them. The fossil-wood group, too, is the smaller and, as regards its organic remains, the simpler of the two, and can therefore be treated by itself more conveniently than in connexion with the lower, from which the organic remains require much additional study and comparison with living species, for which very imperfect facilities at present exist.

The most familiar form in which fossil-wood occurs in the Irawadi valley is that of well rolled and polished pieces of from one to six inches in length, distributed through the coarse shingle which underlies the ordinary alluvial clay of the province and is freely exposed in the bed of the Irawadi at a variety of places, as, for instance, under the station of Thaiet-mio and on the opposite bank under the deserted fort of Miadé. Opposite Prome also a great thickness of this gravel, less coarse than at Miadé, but equally well supplied with well worn and rounded fragments of fossil-wood, occurs, fully 30 feet thick, and rising to a height of about 60 feet above the present flood-level of the Irawadi.*

Besides the ordinarily sized pebbles of fossil-wood, there occur in the gravels towards the frontier, as close to Thaiet-mio, for instance, well rounded logs of silicified wood, some two or three feet or more in length. These, of course, have never travelled very far from their original site, and we accordingly find the parent beds of this quasi-ubiquitous fossil-wood in force but a very few miles from the river, whilst irrefragible evidence presents itself of the former extension of these beds over a much larger area than now occupied by them even as far south as Rangoon in the chips of logs of fossil-wood of a size too great for distant transport, either resting on some lower member of the group, or encased in more recent deposits, the detritus of the beds which originally enveloped them, and with no greater change of position than that wrought by the mere action of gravity during the long process of denudation going on around them.

It is not easy very precisely to describe the distribution of this group without reference to a map, but in Eastern Prome the area it occupies may be taken at something less than

* The coarse character of this gravel or shingle, the well rounded and polished condition of its ingredients, consisting of the hardest silicious rock, and the somewhat mixed size of the pebbles, seem to me greatly in favor of the marine origin of this gravel at a period antecedent to the formation of the present river valley, when the sea was wearing away the shaly rising beds I am now about to describe, though I cannot so much as guess at the source of those silicious rocks of which most of the pebbles consist, so different are they from anything now found in the neighbourhood, or I might say province.

700 square miles, of which not more than a bare fifth or sixth is covered by the highest sandy bed with which the fossil trees are associated, and which from its incoherent character has everywhere suffered to the greatest extent from the action of denudation. There can be no doubt that the entire group formerly extended as an uninterrupted deposit far below the latitude of Rangoon, though the highest member of the group with its associated fossil-trunks does not extend down now in force nearer than 130 miles or thereabouts to that town, or not south of the Tounguyo nulla. The exact termination to the south, however, of this fossil-wood bed is rendered very obscure, by its merging, so to speak, in the debris which has resulted from the waste of the group, and beneath which it sinks and is lost sight of. That it formerly extended much further south is rendered certain (and perhaps the occurrence, *in situ*, of patches beneath the newer accumulations at the present time is also indicated) by the occurrence of large pieces scattered about within the area of the detrital beds above mentioned, of a size such as to preclude the idea of transport from a distance; as, for instance, between the Okhan and Thonsay streams, where a log of not less than four feet in length is embedded in a mass of confused detritus fully 65 miles south of the spot I have assumed as the southerly limit of the group containing the fossil wood *in situ*. Smaller pieces of fossil wood are found much nearer Rangoon and in cuttings in the neighbourhood. These pieces on my first visit to Rangoon, and before I entertained any suspicion of the connexion of the beds at Rangoon and those containing the silicified wood, I was inclined to regard as brought to the spot by human agency, as the Burmese are fond of surrounding their religious buildings with posts of this wood "Engin chouk," but I am now convinced that such is not the case, but that the pieces in question are derived either from the wasted and missing upper beds or from the lower ones of the group still remaining, which, as I shall show, contain the same fossil-wood, though sparingly and never in the same sized pieces as the upper or emphatically *the* fossil-wood bed of the province. Thus the fossil-wood in the Prome district occurs in two distinct formations and under very different conditions, *viz.*, in the form of entire trunks *in situ* or fragmentary pieces, but little rolled, and in well worn or polished pieces, some of large size, but more frequently as pebbles, which form a conspicuous ingredient in the recent gravels.

Below I give, in descending order, a table of the main divisions into which the miocene beds east of the Irawadi may be divided, the upper three of which constitute the fossil-wood group of which I am now treating :—

MIOCENE.

(Descending).

Fossil-wood group.

(a).—Sand—in parts gravelly and conglomeratic—characterised by the profusion of concretions of peroxide of iron associated with it; fossils, trunks of silicified exogenous wood and locally mammalian bones. In the subordinate beds of conglomerate, rolled fragments of wood as above, silicified, (that is, mineralized subsequently to their entombment), mammalian and reptilian bones and teeth of cartilaginous fish.

(b).—Fine silty clay with a few small pebbles mixed with sand in strings here and there the whole very fine and homogeneous and devoid of fossils.

(c).—A mixed assemblage of shales, sand, and conglomerates, the last very subordinate, partaking much of the characters of beds *a—b;* a little of the concretionary peroxide of iron. Fossils, rolled wood silicified; mammalian and reptilian bones and cartilaginous fish teeth. Towards the base, the beds contain marine shells, and pass into those of the next group.

Pegu Group.

(d).—An enormous succession of sandstones and shales of unknown thickness and not usually fossiliferous. Particular beds, however, contain fossils in profusion:

(*e. g.*, *d*-1.—Hard sandstone with corals *(Cladocera).*

d-2.—Blue Kama clay, highly fossiliferous.

d-3.—*Cytherea Promensis* bed or Prome sandstone,

and numerous others which cannot be specified till their fossil contents have been more especially examined).

(*a*).—This bed which we may fairly suppose to have been once co-extensive with the rest of the group is now greatly diminished in area by denudation, which its mineral character even more perhaps than its position at the top of the same has tended to encourage, so that even within the area where it is at present best preserved it by no means constitutes the entire surface, being everywhere deeply scored through to the underlying beds below. The surface is everywhere protected by a gravelly layer composed of small quartz pebbles and ferruginous concretions derived from pebbly strings and irregular courses of conglomerate dispersed through the sand, which readily washing away leaves the residual layer in question at top; to the protection afforded by which against further waste, the existence of what still remains of this incoherent bed is largely due. This surface layer is of variable thickness, its development being, to some extent, a measure of the denudation this group has undergone. On the surface and impacted in it at different depths where it is very thick lie logs of silicified wood of all sizes from a foot or so to trunks of 40 and 50 feet, not entire, but jointed up into pieces of various lengths through spontaneous fracture, probably brought about by their own weight, and irregular subsidence during the removal of the friable matrix wherein they were originally encased. Though, as a rule, these large logs occur as described in a gravelly debris, they sometimes occur relatively to the incoherent sand so as to leave no doubt of its being the bed wherein they were originally deposited, and on which they may be sometimes seen apparently *in situ*, as between Thanat-ua and Kiungee, and not only in this bed but in the beds beneath it, the same fossil-wood occurs, though in smaller pieces, and much less abundantly. The larger logs are quite unrolled, but the smaller pieces are often rounded by transport, though never to the extent seen in the pieces of fossil-wood contained in the recent gravels. When this sand rises into hills, the sides are invariably steep, and not unfrequently scarped, exposing a clean vertical section of sand with its crust of gravel at top. This sand weathers into curious pinnacles wherever an isolated stone, shell, stick, leaf, or other foreign body has afforded shelter from the direct impact of rain, and the incoherent rock all round washing away eventually leaves the protecting substance perched on a slender pinnacle of sand, which recalls the similar phenomenon of the "earth-pillars of Botten" figured by Sir C. Lyell in the 10th Edition of his "Principles."

In color this sand is greyish, very fine and uniform, and with only a certain admixture of impalpable argillaceous matter forming, where exposed to traffic, a fine dust, or, in the beds of streams where the argillaceous portion has been removed by water, a clean silver sand very fatiguing to travel over. Though the sand I am describing unquestionably contains silicified wood, yet it seems probable from the great abundance of large trees strewed over the surface, that they existed more plentifully in that topmost portion which has almost disappeared through denudation leaving only these bulky memorials behind it, than elsewhere. The structure of the wood has been to a considerable extent obliterated by decay before its mineralization was effected, and all that can be definitely said of it is that the wood is exogenous and not a conifer. I have remarked but one species in Prome, though the Burmese, from trivial distinctions in color and weathering, affect to recognise the modern Enjin (*Hopea suava*) and the Thiya (*Shorea obtusa*), an identification of course quite illusory. This wood nowhere exhibits any traces of marine action as might have been anticipated had it floated about till water-logged in a brackish or purely salt estuary, and hence it may be inferred with considerable probability that it floated about in a fresh-water sea, or chain of lakes fed by a sluggish stream, till it sank where it became ultimately silicified. It must at the same time be remembered that the wood found in beds containing marine fossils is also free from perforations, but these are small pieces, much rolled prior to their entombment and probably under conditions on some sub-marine bank unfavorable to the presence of either *Pholas* or *Teredo*. In some pieces of fossil wood I have noticed minute tubular cavities (perforations?) about ·02 or less in diameter, which might have been produced by some insect whilst the trunk was still standing, but such cases are rare. Associated with this sand, and forming sometimes irregular beds in it, or more frequently lenticular courses, now thickening, now thinning out, occur some hard sandstones, sometimes very fine grained, at others a pebbly grit, or even coarse conglomerate. No regular position in the sand can be assigned to these subordinate layers, but the fine hard sandstone often occupies a high position in the deposit, whilst a coarse conglomerate is not unfrequently met with towards its base. Both sandstone and conglomerate are usually richly charged with shark's teeth of small size (*Lamna*), the conglomerate being usually ossiferous as well, though throughout the deposit the occurrence of bones is irregular, capricious, and local.

A good section displaying the relation of these grit-courses to the less coherent rock around them, is seen in the hills about three miles east of Shuebandor, or about fifteen miles east of Alán-mio. The hills are here steeply cut in the bed I am describing, the surface being covered with the usual gravel, with abundance of silicified wood and ferruginous concretions, the former completely blocking many of the deep gullies cut on the hill side. Strewed about here may likewise be seen numerous lustrous fragments of iron slag, from the native furnaces once scattered over these hills. The sand here presents its usual incoherent, typical character, but a compact sandstone, passing into a coarse grit in patches, is somewhat freely developed in irregular lenticular courses in it. On the surface of the incoherent sand at this spot, and evidently weathered out of it, I picked up a fragment of the lower jaw of a deer, and from the immediate vicinity I collected mammalian bones, mostly ill preserved and fragmentary, shark vertebræ and teeth, and chelonian plates (*Colossochelys* and two species of *Emys).* In the great slabs of grit lying about amidst the debris of the wasting sand which enveloped them, shark's teeth were plentiful, accompanying mammalian bones and fragments of wood, many of which had been perfectly rounded by attrition before they were embedded. These pieces of wood are, however, not common. Another locality where bones are still more abundant is one-half mile north-east of Talok, or fourteen miles north-east of Thaiet-mio on the east bank of a stream not marked on the map. Bones are here far from scarce, but friable and ill preserved. They occur both in the incoherent sand and also in the coarse grit and conglomerate associated with it, together with shark's teeth and small pieces of wood. At this spot there is a good deal of coarse conglomerate, and in accordance with the indications afforded by these coarser beds we find the bones of a larger size, and many of these much rolled and abraded before they were finally embedded. Here I got a fragment of the lower jaw of an elephant, together with fragmentary portions of the limb bones of that animal, all imperfect either from original violence or subsequent decay, the former cause certainly operating in some instances.

I may here remark that the bones found in this group (within the area I am now concerned with) are not all in the same mineral condition. The majority are somewhat imperfectly mineralized and consequently decay very readily when bared to the atmosphere by the wasting of the surrounding rock, and this I am convinced is the reason of so few bones being found on the surface, even in spots where the rock is seen to contain them somewhat plentifully. A few fragments may here and there remain, but most of the bones noticed by me were so tender, that it was clear that a short exposure to atmospheric action would reduce them to crumbling masses, which would break up and leave scarcely a trace behind them. A bone is, however, here and there found in the water courses well mineralized and calculated to defy atmospheric action, but the scarcity of these fragments attests that such is not the usual condition of bones in these beds. That these well mineralized bones are derived from the same beds as the more friable ones is undeniable. The best mineralized bone perhaps met with was the part of a deer's jaw above mentioned, and this most certainly was derived from the soft incoherent sand whereon I picked it up. The astragalus of a ruminant *(Cervine?)* found also by me during a former season, was in like manner an isolated example of well preserved bone, though being found in a small stream its parent bed was not demonstrable. In Upper Burmah well mineralized bones are probably more common to judge by those which have been at various times collected there, and the difference is merely the result of different conditions at the time of their deposition, such as we might expect to prevail, and depending probably on the irregular access or supply of silica in solution. That the supply of this silica must have been at some period abundant is testified by the enormous amount of silicified trunks everywhere met with, but the horizon of these is certainly higher than that at which the bones in question occur, and although small pieces of silicified wood occur commingled with the bones, it does not therefore follow that the same abundant effusion of silica took place at the time of their deposition as subsequently occurred when whole forests were silicified, and this I should be inclined to regard as the true explanation of this condition of *most* of the bones in this sand, *viz.*, an insufficient supply of silica in solution.

As a rule, it is not, however, in the sand but in the coarser and more conglomeratic beds that the bones seem mostly to occur, of which a good instance is seen midway between Omouk and Lema, some 19 miles east-south-east from Thaiet-mio. Here a great bed of conglomerate is seen dipping 30° south-east in which I noticed the tusk of a small elephant, but too friable to be extracted from its hard matrix, together with other bones, all in a poor state, and more or less injured by rolling about on a coarse shingle before their final consolidation.

Next to the presence of silicified wood, a remarkable development of concretionary peroxide of iron seems to characterise the sand I am describing. The ore occurs occasionally as a thin band, up to perhaps a thickness of three inches, breaking up or jointing into rhomboidal concretionary masses of different sizes and shapes. More usually the ore occurs in the form of variously shaped concretions from one to four inches in length, though occasionally even larger. These concretions are found in both the sand and conglomerate, to which last when numerously developed they impart a peculiar varnished look, which might sometimes be almost styled (but for the technicality of the term) viscous or slaggy. The more usual shape of these concretions is flattish oval or amygdaloidal, but they occur spherical, cuboidal, cylindrical, with both flat and hemispherical ends, discoidal and any intermediate form, but always symmetrically proportioned, and the result of a segregative action or process in the clayey and ferruginous components of the bed when in a plastic condition. Of whatever shape however, their structure is extremely uniform, consisting of an external crust of concentric layers of brown hæmatite surrounding a kernel of pure white or yellowish clay, lying loose and shrunken in the interior.

Externally these nodular concretions are roughened from the adhesion of the sand enveloping them, but this rough crust scales off readily, leaving their surface perfectly smooth. Internally they often present a blistered appearance from the mammillary crystallization of Limonite which lines them, becoming on exposure to the atmosphere and rain lustrous and varnished. Where the bed has been of too harsh a character to permit the regular segregation of the ore, it is found lining sinuous cavities in the coarse matrix, leaving flat, approximating walls, evidently produced by shrinkage, which gives such portions a very peculiar aspect and one which simulates a viscous condition. In some places even a botryoidal structure is induced where the rock is less coarse.*

The thickness of this upper sand cannot be closely estimated, but 40 feet is probably more than the average thickness of what now remains of it.

(b).—Below the last described sand occurs a deposit of very uniform character composed of pale silty clay which passes upwards into the overlying sand. This silty clay is very fine, thin bedded and homogeneous, with merely a few strings of sand here and there, and an occasional small pebble in the sand. It is everywhere seen at the base of the last bed into which it seems to pass, though their respective characters constitute a good means of demarcation between them. It is entirely devoid, as far as observation goes, of organic remains. A good section of this silty clay is seen south of Thanat-ua, between Alán-mio and Kiungalé, but the bed presents no special point of interest.

It is also largely exposed in section 1½ miles east of Talok on ascending out of the stream (previously noticed as unmarked in the map), but it merely presents the same uniform character and absence of fossils, which distinguish it elsewhere. Where the upper sands have been completely denuded so as to leave exposed a large area of this bed, an undulating country is the result, possessing a marked character. The surface of the country does not there greatly differ in appearance from that seen within the area of the alluvium, and it would not

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* Under the Burmese rule this ore was extensively smelted, but no furnaces are now anywhere at work in the district. Remains of furnaces which were merely rectangular kilns, cut in the firm alluvial clay of some steep bank, which gave easy access at top for replenishing ore and fuel, and below for withdrawing the products, are numerous about Shuebandor, Kiungalé, and Yebor, together with slag-heaps, sometimes of no inconsiderable dimensions. Throughout the area of these upper sands, however, slag may be found here and there scattered about, as the iron-workers shifted their scene of operations from spot to spot, wherever charcoal and ore was for the time most plentiful. The works must have in many cases been conducted in the dry season only, as the hearths of some furnaces still standing open into the beds of streams which during rain would certainly have found an entrance to them. The blowing apparatus was probably the effective *vertical cylinder* bellows formed of large bamboos still in use in the district by blacksmiths, but the oldest inhabitant could give me no particulars of the manufacture, as none of the class of iron-smelters now remain in the district. The introduction of English iron and steel has doubtless been the main cause of the abolition of this branch of industry, aided by the harsh and injurious system of the Burmese officials during the early struggles with the British, but in some places it was alleged that the iron-workers had fled the country to avoid being forcibly transported to Calcutta to make iron for the terrible *foreigners*. This may seem very absurd, but those who know the ingrained credulity and ignorance of Asiatics will be inclined to give some weight to the reason stated, though it is probable that this fear, strongly as it may once have operated, is no longer felt, though the state of the market and the price of iron now ruling in Pegu prevents the resuscitation of the trade.

be easy in a limited space to discriminate the clay in question from the ordinary alluvial clay of the valley. Where, however, freely exposed, it presents much the appearance of a 'regur,' save in color, which is a pale yellowish-gray, quite devoid of any tinge of red which the alluvial clay generally possesses, and equally so of the dusky carbonaceous hue of a regur. From some peculiarity in its composition or hygrometric qualities it in dry weather opens out in great cracks, and is always covered with a sparse crop of stunted grass in separate tufts, and a tree jungle of a peculiar aspect from the dwarfed character of the trees composing it, present among which are the Toukkian *(Terminalia macrocarpa)*, Te, (*Diospyros.* sp.), and the "Shábiu" of the Burmese *(Phyllanthus emblica)*.* The country around Laidi comprising the doab between the Pade and Myo-hla streams is composed of this clay with sparing remnants here and there of the upper sands. It is largely exposed, too, in the broad valley about Lepaláh (Let-pan-hla) and between that village and Chouk-soung ("stone fang"). Towards the mouth of the Myo-hla stream near Toukkian-daing, (Htouk-kyun-deing,).this clay forms the open country and is dug for making pottery. It might here be readily mistaken for the alluvial clay of the valley, but for the occurrence here and there strewed over it of small pieces of silicified wood derived from the denuded sands which once covered it. The thickness of this bed I cannot estimate, but I should not place it under 40 feet; how much more cannot be determined.

(c).—Below the last described clay, a group of beds occurs of rather varied character, resembling, to some extent, the beds both above and below it. It contains, though sparingly, the same description of fossil wood as the sands at the top of the group, and some of its beds present characters very similar to portions of those beds; whilst towards its base, it appears to pass insensibly into the lower group characterised by marine fossils. It is, however, generally very devoid of organic remains, though, as a convenient lower horizon to it, I have taken a sandstone which is generally recognisable where the junction is clear, by a few organic remains not very well preserved, among which a coral *(Cladocora)* is most characteristic, which we may regard as the highest member of the lower group.

A section of these beds is seen in the Kini-choung (Kyeeneech') above Mogoung, which may be taken as illustrating their general character, and some portions so resemble the ossiferous sands and gravels of the upper beds that I searched confidently, though in vain, among them for like fossils.

(Descending).

Pebbly sandstone	seen, about ...	50	0
Pale silty shale	...	3	6
Very false-bedded pebbly sandstone	...	16	0
Harsh sandstone, rather irregular	...	0	1
Compact yellowish silt with a central band of kidney-shaped nodules 1 to 2 feet in diameter	...	2	0
Gravelly sand	...	0	2
Yellow pebbly sandstone	...	3	0
Pebbly conglomerate, loose and gravelly	...	(a few feet).	
		74	9

'This section, though not a thick one, will illustrate the general character of the upper portion of this division *(c)*. The silty shale much resembles the shale in division *b*, whilst the sands equally recall the uppermost sands, *(a.)* Close on the horizon of the above section

* The clay above described and the sandy beds of the same group, respectively, offer good instances of the connection of particular soils with particular kinds of vegetation. So generally does this hold good in Pegu that in some instances it affords a good empirical criterion of the geological formation beneath. In the area of the fossil-wood sands, the most prominent tree is the Eng *(Dipterocarpus grandiflora)*, and this tree so commonly affects a sandy soil that the Burmese call such soils, whether within the limits of the fossil-wood sand proper or, the zone of detrital accumulations skirting the hills, "Engdaing," or the tract of the Eng tree, and though, of course, Eng trees are found on other descriptions of soil, yet it is on this sandy belt that the Eng flourishes most vigorously from probably being there less competed with by other trees, well fitted as it for a sandy soil. The "Thiya" *(Shorea obtusa*, Wall,) the "Kanyin" *(Dipterocarpus alata*, Wall,) and the "Engyin" *(Hopea suava*, Wall,) equally affect the sandy "Engdaing," though not in sufficient numbers to characterize the forest. On the other hand, these trees abhor the clay described above and are most miserably dwarfed on it. The Toukkian *(Terminalia macrocarpa)*, though dwarfed, seems to answer best on this clay, but from some cause or other it does not seem favorable to vegetation. I think this must be due rather to its hygrometric properties, than to any injurious ingredient in it, and that if artificially irrigated, it would give better promise to the cultivator than the densely wooded sands to which it offers so unpleasant a contrast.

Bamboos are not usually much developed on the Engdaing, and a striking demarcation is not unfrequently seen where the Engdaing meets the boundary of the older beds on which bamboos flourish with great luxuriance. The Burmese are fully alive to this fact, and if an enquiry is made regarding a village, say, if it stand within the Engdaing, will answer it negatively, "it is among the bamboos," an expression quite equivalent in their minds to saying it is *not* on the Engdaing where bamboos are rare and never are the characteristic vegetation.

must probably be placed the ossiferous beds, at the top of the river reach above Talohmhor (Keng-yua in map), yellowish sands pebbly at top and passing up into rather soft conglomeratic sandstone containing bones, both mammalian and chelonian, shark's teeth and vertebræ, fossil-wood and rolled fragments of oysters and other shells.

A small but instructive section is also seen of these beds in the Myouk Naweng, a little below Thambyagon (Tham-bya-ga-gon), where pale silty shales are seen supporting a great thickness of rusty incoherent sand traversed by thin layers of shale and a coarse quartzose conglomerate with clay galls and cavernous hollows incrusted with a layer of the brown hæmatite, as seen in some sandy beds of the upper division *(a)*. In this conglomerate I found mammalian bones, shark's teeth, and a small log of fossil-wood about two feet long of very similar character, though less completely mineralized than that found so abundantly in bed *a*. No other fossils were discernible here, nor, as a rule, throughout this division, though towards its base, sandstones come in containing marine shells and corals, though neither plentifully nor well preserved. These marine beds, however, are naturally more connected with the great group which follows immediately below the present, and which nowhere contains the fossil-wood so characteristic of the present group.

It only remains to add a few words on the very close restriction to the eastward of fossil wood after leaving the area of the fossil-wood group. Nowhere within the area occupied by this group is fossil wood, in pieces of the largest dimensions, more liberally distributed than along the eastern margin of the deposit along which it is everywhere found abundantly, but directly the boundary of the group is passed there is an almost complete absence of fossil wood, even in moderate sized pieces. A very close and careful search in some of the larger nullas may result in finding a piece here and there for some few miles from the boundary, but that is all, and the question at once presents itself,—has this fossil-wood sand extended formerly across the ranges to the eastward and to the Sittang Valley, or was its extension in that direction limited by a boundary somewhat corresponding in its general direction with the present boundary of the group? Without any detailed knowledge of the extent of the group on the eastern side of the Pegu range, we know the single fact that this fossil-wood group occurs in the Sittang Valley, and this and the presumed conformity of it with the lower group which constitutes the bulk of the intervening ranges of hills, would strongly lead us to regard the group as having once stretched uninterruptedly from the valley of the Irawadi across that of the Sittang, or over the entire country bounded to west and east, respectively, by the Arakan and Poung Loung chains. That this must have been the case with the great bulk of miocene rocks so largely developed in this part of the Irawadi Valley is certain, but one argument, though a negative one, is, I think, sufficient to make us pause before accepting the idea of a continuous extension of the fossil-wood bed over the same area as those of the group below it. This argument is the absence which I have alluded to of fossil wood for a distance not far short of 50 miles, that is, throughout the entire breadth of country occupied by the precipitous hills and tortuous streams of the Pegu range. When we reflect on the large size of some of the silicified trunks which may be said to strew the country along the eastern boundary of this group in Eastern Prome, and the abrupt cessation of any save the veriest traces thereof, and these but for a short distance from the boundary, and consider also the imperishable character of much of this fossil wood as evinced by its abundance in the hard and well worn gravels of the Irawadi Valley, we are irresistibly led to question the former extension of this fossil-wood bed across a belt of country wherein it has left no traces. The evidence is about as forcible as negative evidence can be. Additional weight is also given to it by the fact, that its admission presents no difficulties, but quite harmonises with the process which the geological history of the district seems to indicate as having occurred. We have only to suppose that the deposition of the vast series of miocene rocks developed in Pegu proceeded uniformly (during, possibly, a synchronous elevation, in a gradual manner, of the ocean bed) till the entire series, save the topmost members, had been deposited. Lacustrine conditions we may now presume to have supervened over portions at least of so large an area, and the elevation of the Pegu range of hills commencing about this time would cause the first land to appear on a low belt of country occupying in its general arrangement the present line of the Pegu range. In other words, the deposition of the uppermost beds of the group and notably of the fossil-wood sands would be arrested along a line of country not greatly differing from the present boundary of the group. The elevation of the Pegu range and its corresponding disturbance of the adjoining strata certainly continued down to a period subsequent to the final deposition of the fossil-wood group, though from the mineral character of the upper beds, any movements they have been subjected to are with difficulty determined, and these movements may have, to some extent, interfered with the effect of a *coup d'œil*, but from several points of elevated ground beyond the area of the fossil-wood beds, I have been struck by the manner in which those beds were spread out; on a lower level, in a fashion strongly suggestive of their accumulation under lacustrine conditions along a stretch of elevated country almost coincident with the present boundary. This is notably the case at the extreme north of the district near the British boundary above Teybin and Bilugon, and is also to be remarked elsewhere, though the forest is so dense that it is rarely one is able to get a glimpse of any large extent of country. Had it been otherwise than here supposed, it would be extremely hard to understand how the imperishable testimony of fossil-wood logs and fragments had been so completely removed from the hilly tract, where as a matter of fact they are wanting. They are certainly the hardest bodies met with, and having held their own among the quartzose rocks which comprise the bulk of the Irawadi gravels, must, *a fortiori*, have no less successfully withstood the destructive action of denudation amidst the softer miocene beds which alone are met with in the Pegu ranges. I need not, however, dilate more on this subject, which will be readily enough cleared up when the geology of those regions above the present British frontier comes to be carefully examined into which these fossil woods extend, and wherein they seem to be more largely developed than within British territory.

MINERAL PRODUCE OF INDIA.

Towards the close of the year 1868, I solicited from the Commissioner of Kumaon (and some other officers) information as to the quantity and value of the minerals raised and brought to market within their jurisdiction. Such local operations, where minerals are raised solely for local use, and in reality are never exported, or, only in very small quantities, even transported from one district to another, taken separately, are of small importance, but when aggregated for the country at large, they represent an amount and value which must be very considerable. And these small local mining operations can only become known by the assistance of the local officers. To Colonel H. Ramsay, C. B., Commissioner of Kumaon, I am indebted for the returns now given for *Kumaon* and *Gurhwal.* The information has been collected, under his orders, by Mr. Lawder, Civil Divisional Engineer, Kumaon. Mr. Lawder was for several years one of the office staff of the Geological Survey, and possessed, therefore, a general knowledge of the subject referred to him, and has evidently devoted himself with zeal to the collection and preparation of information.

I was, I confess, surprised at the quantities stated to be raised and the extent of the mineral industry. Viewed merely as a source of employment of labour, these returns show the equivalent of the continuous labour during *every day in the year* of no less than 154 persons, and yet the effect is scarcely felt beyond the narrow limits of the province itself, excepting in so far as this local supply obviates the necessity for imports of materials from elsewhere.

MINERALOGICAL STATISTICS OF KUMAON DIVISION, collected under instructions from THE COMMISSIONER, COLONEL H. RAMSAY, C. B., by A. W. LAWDER, ESQ., Civil Divisional Engineer.

My endeavours to collect reliable memoranda of the mineral resources of Kumaon have not been so successful in their result as I could have wished. The entire absence of reliable native information, and the general unwillingness exhibited by the inhabitants to speak at all on the matter, arising from the fear that any knowledge they might communicate would perhaps eventually be the cause of increased rental demand or of the appropriation by the Government of the land in which the minerals occurred, have presented many difficulties. The information obtained from the Bhoteeas was given with great reluctance.

Owing also to my having but little surplus time to devote to the full elucidation of the subject, the memoranda supplied here are doubtless somewhat imperfect and incomplete; my duties, although carrying me to all parts of the Kumaon district, confine me (with some exceptions) more particularly to the roads, and I have probably repeatedly passed by old mines, or places rich in minerals, in utter ignorance as to their existence, not to mention other places remote from any frequented thoroughfare.

In the following notes I am indebted to reports already published for much information.

The principal economic products in the Kumaon Division are the following: gold; copper; lead; iron; arsenic; sulphur; alum; lignite; bitumen; limestones; flags; slates, &c., &c.

DETAIL OF LOCALITIES.

Kumaon District.

COPPER.—Ores of this metal are found at Rai in Gungoli, Síra Barabísí, Kharai, Kemokhét (each bank of Luddya river), Geewar, &c., &c.

Rai.—This mine is the principal one in the Puttí. The ore is chiefly pyrites, and occurs in a matrix of steatitic and talcose schist. I visited these mines in the winter of 1868-69, and found the mines closed up by a landslip, and the entrances full of water. The ore is extracted by means of drifts slightly inclining upwards to allow for drainage, as appears to be the mode most generally adopted throughout the hills. A specimen of ore which I found on the spot seemed rich. I also discovered slight traces of copper pyrites in quartzite near Gunai in Athagaon Puttí.

Síra Barabísí.—Síra is noted for its copper mine. Dolomitic and talcose rocks form the gangue. The ore is a mixture of copper and iron pyrites.

Kharai.—Goul is the principal mine. The ore is worked in the same manner as at Rai. Steatite and limestone are the neighbouring rocks, the former being the matrix principally.

Kemokhét.—Copper is found in small quantity on the east bank of the Luddya river in Kali Kumaon. I have seen no specimen of the ore.

Geewar.—There is a small mine of copper in this Puttí.

At Gurung and Chinkakolly there are mines which have been closed for some time; also at Beler and Shore.

IRON.—Iron is found in Dhuniakote, Agar, Geewar, Kutolí, Ramgurh, Tullí Rao, Chowgurka, &c., &c.

Dhuniakote.—There are the remains of some mines or burrows just opposite the staging bungalow on the left bank of the Khyrna river. The ore is hæmatite, occurring in irregular masses in quartzite. The rocks in the neighbourhood are more or less impregnated with oxide of iron. These mines are now unused.

There is also a mine south of Semulkha in this Puttí, and another in Utehakote, both now unworked.

Agar.—This Puttí is very rich in iron ore, almost every village having its mine. The ore seems to be a brown hæmatite. It occurs here generally in beds or clefts, and sometimes in irregular masses. The rocks in the vicinity are silicious. Only a few of these mines are now worked to any extent.

Geewar.—Iron occurs in quantity in the neighbourhood of the villages Khetsari, Maelchour, Tilwara, Simulkhét, Gudí, and Burlgaon. I can give no opinion as to the kind of ore, having no specimens.

Kutolí.—At Suyalgurh there is some iron ore which is not at present worked to any extent.

Ramgurh.—There are several mines in this Puttí, some largely worked.

Munglalékh.—This mine in Tullí Rao Puttí is highly esteemed for the quality of its ore, which is raised in quantity.

Chaugurka.—The ores of iron are plentiful in this Puttí, and are worked in some places.

At Jhirratolí in Darún the ore is magnetic.

Dechouree and Khúrpatal.—There is not, I believe, any ore, being at present worked by the Kumaon Ironworks Company.

GRAPHITE.—This mineral crops out at Kaleemut hill to the north of Almorah in the Jagésur range, and on the spur of Baninee Devee, facing Almorah on the Lohughat road.

Gurhwal District.

GOLD: Sona River.—This stream rises in the lower ranges of hills, and joins the Ramgunga river in Puttí Dhún. Its sands yield gold, and the bed of the Ramgunga below the junction is auriferous. The washing is not very profitable, scarcely averaging 4 annas a day to each workman.

Taluka Chandí.—The sands of the Ganges running through Chandí contain gold, but the profit arising from the washing is not greater than in the Sona river.

COPPER: Dewalgurh.—The Dhanpur and Dhobrí mines yielded largely in former times, but of late years operations have not been so vigorously carried on, owing to the intricacy of the workings, and the idea prevailing among the miners that very little ore remains in the mines. The ores are principally copper pyrites, and grey or vitreous copper ore, with the red oxide and green carbonate in smaller quantities. The matrix is calcareous. Galena is associated with the copper ore.

Nagpúr.—There are several mines here none of which appear to be at present worked.

LEAD: Dhanpur; Tacheeda.—These mines do not seem to be extensively carried on. The ore is galena, and the matrix principally of silex, with varying proportions of felspar and calcspar.

There are some lead mines at Ghertee in the snowy range between Milum and Niti which have been long since deserted, also at Rallum, Bainskum on banks of the Goree river, and Baidlee Baghir.

IRON: Tullí Chandpoor.—This ore is probably a hæmatite with a little magnetic iron. It has a slight repelling action upon the needle.

Tullí Kalíphat.—This specimen resembles specular iron ore.

Mullí Dussolí.—The specimens are highly magnetic and rich in ore.

Tulla Chandpúr, Rajbúnga.—This hæmatite ore is largely worked.

Nagpúr.—This ore gives no definite result with the ordinary rough tests. It may possibly be a carbonate of iron.

Lohba.—Here a rich hæmatite is raised in quantity.

Mulla Nagpúr.—The ore is most probably hæmatite.

Painu.—This ore is brittle and hard, and possesses the iron black colour and metallic lustre of magnetic iron, but the specimens of it failed to affect the compass in the manner characteristic of that ore. It may possibly on analysis be found to contain manganese, and if so, it will be an interesting mineralogical discovery.

Iriakote.—It is difficult to say what form of ore this is. Its streak fails to convey a definite idea of its composition. It would appear to be an hydrous form of sesquioxide of iron.

Pokrí.—These mines have been reported on by several officers.

SULPHUR.—This mineral is found both in Kumaon and Gurhwal. In the former district at Moonsyaree, in the northern parts of the district, and there are also some sulphureous springs, as that at Nynee Tal. In Gurhwal it is found in the range of hills to the north of the Pindur river within a couple of marches of Nundpriag; also at Mulla Nagpúr and Mulli Dussolí, but is not now collected to any extent.

ARSENIC.—Yellow arsenic (*Hurital*) is found in the northern parts of the district near Moonsyaree. Only small quantities are brought down to the Bagésur Fair by the Bhooteas.

LIGNITE.—Indications of lignite appear near Raneebagh, close to Huldwaní, and in the streams of the sub-Himalayas north of Nujíbabad. They do not give promise of any workable fuel, and judging from the experience obtained in other parts of the hills, it is questionable whether any lignite deposits will ever be discovered of such extent that they will repay the cost of opening them up.

An analysis of a specimen of the Ranibagh lignite gave—

Carbon	60·0
Volatile matter	36·4
Ash	3·6

The percentage of ash 3·6 contrasts favorably with that of the ordinary Indian coal raised in Bengal. The ash is colored by the presence of iron.

Bitumen or mineral resin (*Salajit**) occurs near the summit of many mountains where it exudes from crevices in the rocks.

In the neighbourhood of Kotegaon, Gowarseo, south of Paoree, it is seen near the top of large cliffs, and is worked by natives by means of a scaffolding suspended from the summit. I am unable to state the amount of it extracted. It is generally used as a medicine and exported to the plains. Medicine from *Salajit* is also prepared in Gunguli in Kumaon, but I have been unable to ascertain from whence the mineral is originally obtained.

Limestone.—The Kumaon hills are prolific in limestones, occurring both in immense masses, exhibiting various shades of color and structure, and as local Tufa deposits.

In the newer geological formations of the lower hills it occurs sometimes as a light colored rock, and sometimes as the cementing material in conglomerate beds and very frequently as Tufa deposited by local springs and streams. The process of deposition is most active during the monsoon rains, and in nearly all the springs emanating from limestone rocks, the waters are highly charged with calcareous matter.

These tufaceous deposits occur less frequently in the higher ranges, but there the blue hard limestones generally containing silex, and other hard varieties, prevail, forming well defined beds, and in many instances they are the predominant rocks of some of the larger hill runs. Small blocks of very pure black limestones are sometimes to be met with, and I have picked up some small nodules of kunkur in the Luddya river.

The principal material utilized by the natives of this district is Tufa, it being more easily burnt and prepared, and more suitable to the kutcha kilns in ordinary use. Where it has in its composition a little iron it seems to yield a strong mortar.

The localities in which lime is manufactured are very numerous, the most important being Naini Tal and Jeolí for use in the neighbourhood.

In the Kharai range, half-way between Bagésur and Almorah, from which the latter station is almost wholly supplied. At Chitailí, in the hills north of Dwara Hat; at Simulkha, Baital Ghat, and Dekolí, in the Kosí valley, for consumption in the works in progress in the new military station at Raníkhét, and on the new cart-road from thence to Ramnagar. There is also lime, somewhat silicious, in Agar Puttí, in the Retha Gâr range, Athagaon, and in almost all the hills in Gunguli. At Ramésur it skirts the road for miles.

It also occurs near Khyrna on the Almorah road, at Mulwa Tal, and in Geewar, &c.

Roofing Slates, &c.—Roofing flags are very plentiful in the district of Kumaon, and are generally micaceous or chloritic.

At Chitailí near Dwara Hat there are some beds of imperfectly metamorphosed clay slate, the planes of cleavage seeming to occur almost in the same lines with the bedding. The quarry was formerly used to some purpose, but owing to the neglect of former owners, it has been for years filled up with debris, so that I was unable to observe the beds properly.

Clay slate occurs also in the neighbourhood of Naini Tal, but the cleavage is imperfectly developed. There are a couple of quarries on the banks of the Ramgunga in Sult Puttí.

Building Stones.—Almost everywhere in the district within easy reach good building stone is to be had. At Almorah fine-grained evenly-bedded quartzites and mica schist form the hill itself, and supply material not to be excelled for

* Mr. Lawder is here in error in calling *Salajit* bitumen or mineral resin. It is an alum or native sulphate of alumina which forms on the aluminous shales in the hills. At least such is the *Salajit* of Nepal, where it is well known and from which it is more largely exported than from Kumaon. Wonderful medicinal virtues are attributed to it, and in the plains it often sells for its weight in silver (see Notice of a native sulphate of alumina from the aluminous rocks of Nepal, by J. Stevenson, Esq., Supt., H. C. Saltpetre Factories; Journal, Asiatic Society, Bengal, Vol. II, p. 321. Also On the alum or Salajit., of Nepal, by A. Campbell, Assistant Surgeon, &c., &c., *ibid*, p. 482; also a second note by Mr. Stevenson, p. 605). Whether the mineral referred to by Mr. Lawder be really the same as *Salajit* I cannot assert.—T. Oldham.

durability and facility of dressing. Mica schist seems to form the principal beds for some distance to the east and west of **Almorah**, reaching to **Dwara Hat** and **Massí** on the west, **Palí**, **Raníkhét**, **Síahí**, **Deví**, **Dole**, and towards **Kalí Kumaon** to the east, and also in the formation of the **Jagésur** and **Binsar** ranges to the north.

At **Nainí Tal** the stones used are limestone and clay schist.

At **Raníkhét** a pale colored gneiss forms both a handsome and a lasting building stone.

Sandstone is abundantly found in the lower hills.

Gneiss and chlorite schist are used frequently as building stones in the district.

Imports.—The chief importations are BORAX (Tincal), SALT, and GOLD from Thibet.

BORAX.—Borax is obtained from the borders of a lake at **Chappakanni**, a few koss from the **Kylass** mountain in Thibet.

It is collected from June to September and sold at the several fairs—**Ganpa**, **Gupa Chín**, **Sibbillum**, **Chakra**, **Taklakhal**, **Dhabakar**, &c. It is purchased here by the Bhootea traders and brought down to Bagésur. At these fairs the price of crude borax is something under 2 Rupees per maund (about 50 seers), and in the same state it fetches from Rs. 8 to 9 per maund at the **Bagésur** Fair, which is the chief mart of the **Jowarí** traders. The borax bought up here is despatched to Ramnagar, where it is refined and redisposed of at about Rs. 22 to 24 the maund.

Traders from the **Byanse**, **Chowdanse**, and **Darma** Passes transact sales of borax at **Dharchula** and **Burmdeo**, and the Gurhwal Bhooteas from **Niti** at **Kanaseo** and **Ramnagar**, nearly all the borax is disposed of to plains traders—

Probable amount of borax brought through **Milum Pass** in 1868-69	...	17,000 mds.
Probable amount of borax brought through **Darma** and **Byanse** in 1868-69	...	15,000 „
Probable amount of borax brought through **Niti** and **Mana** in 1868-69	...	15,000 „
TOTAL	..	47,000 mds.

SALT.—Is found at **Rhuduk** in Thibet, and is sold at the same fairs as borax. It is also found at **Silungsakka** in Thibet—

Probable amount imported *viâ* the **Jowar Pass (Milum)** in 1868-69	...	4,000 mds.
Probable amount imported *viâ* **Darma** and **Byanse** in 1868-69	...	3,000 „
Probable amount imported *viâ* **Niti** and **Mana** in 1868-69 ...	...	2,000 „
TOTAL	...	9,000 mds.

Salt is purchased in Thibet at the rate of 1 Rupee 12 annas per maund (roughly measured) and sold at Bagésur or Almorah at from 5 to 6 Rupees per maund. Almost all the salt imported from Thibet is consumed in the hills.

GOLD.—Is found in many of the rivers in Thibet; at **Silungsakka**, &c.; it is sold at the same fairs as the salt and borax either in nuggets or in grains. About 10 to 12,000 Rupees' worth is brought down annually, some of which is disposed of in the hill districts (**Kumaon** and **Gurhwal**), probably about one-third, and the remainder most likely finds its way to **Delhi**, **Agra**, &c., &c. It is sometimes found to contain copper.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah KUMAON *for the year* 1868.

Name of Putti.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of lead.	Mines of slates.	Mines of lime.	REMARKS.
					Maunds.	Maunds.	Maunds.	Maunds.					
Kutowlí	Suyalgarh ...	Iron ...	By digging rock.	600 *	1	50	9	7	Salt, borax, gold imported from Bhoot, north of Kumaon. Copper chiefly imported from plains.	There is one mine of lead in Puttí Kharai, which is lying unworked.	There are many mines of slates in the district.	There are eight mines of lime, one in Kharai, one in Geewar, one in Kosyan, and one in Boraran, one in Shore, one in Síra, one in Dhyanirao and one in Charal.	Partly sold in the neighbourhood and partly brought to Almorah and Huldwaní.
Ramgarh	Dusonla ...	"	"	4,200	200	300	150	150					Bageesur, ditto ditto.
	Buna ...	"	"	2,000	90	140	70	70					Ditto, ditto ditto.
	Pálí, &c. ...	"	"	2,200	110	160	80	80					Ditto, ditto ditto.
Agar	Pathora ...	"	"	4,000	130	200	100	100					Ditto, ditto ditto.
	Mujera ...	"	"	4,400	100	300	100	150					Ditto, ditto ditto.
Geewar	Ketsarí ...	"	"	8,800	100	600	200	200					Ditto, Ramnagar ditto.
	Goodí, &c. ...	"	"	8,000	50	700	200	200					Ditto, ditto ditto.
Burson Gungúlí ...	Raní	Copper.	Deep shaft.	3,840	1	10	8	8					Ditto, ditto ditto.
Burra Gungúlí ...	Belarh ...	"	"	200	1	1	1	1					Ditto, ditto ditto.
	Lettí, &c. ...	"	"	540	......	1	2	2					Ditto, ditto ditto.
Kharai	Goul	"	"	2,200	......	2	...	6					Ditto, Thul ditto.
Barabísí, Síra ...	Haralí ...	"	"	3,840	1	3	8	10					Ditto, Shore, Ramésur ditto.
	Puthrowlí ...	"	"	200	......	1	1	1					Ditto, ditto ditto.
Tullí Rao	Munglalékh ...	Iron ...	By digging rock.	4,200	200	300	150	150					Ditto, Burmdeo ditto.

* These numbers express the number of men for one day.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah GURHWAL *for the year* 1868.

Name of Puttí.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Mines of sulphur.	Mines of slates.	REMARKS.
Dhanpúr	Dhanpúr	Copper...	Deep shaft	1,200	Quantity not discoverable.	Not sold, but worked on spot.	Not melted yet.	None.	There are two mines of sulphur in Mulla Nagpúr and one in Mulla Dusowlí which are all lying unworked.	There are many mines of slates in the district.	Partly sold in the neighbourhood and partly brought to Sreenagar Bazar.
Ditto	Tachída	Lead ...	”	100	3 mds.	8 mds.	...	...			Sold at Sreenagar.
Tullí Chandpúr ...	Sakund	Iron ...	”	600	60 ”	...	7 mds.	...			Is sold within the Puttí.
Tullí Kalíphat	Rajkhan	”	”	50	24 ”	120 ”	20 ”	...			Ditto ditto.
Mullí Dusowlí	Dumtí	”	”	200	100 ”	100 ”	30 ”	30			Purchased by the people of native Gurhwal, Barasyún, and Sulan.
Ditto	Kalabun and Mokh ...	”	”	500	400 ”	400 ”	100 ”	100			Ditto ditto.
Sílí Chandpúr	Rajbínga	”	”	1,100	...	120 ”	15 ”	...			Sold within the Puttí.
Boongí	Buwaní	”	Collected from different marts.	120	20 ”	20 ”	...	...			Ditto ditto.
Lohba	Simulkhét	”	Deep shaft	2,250	400 ”	1,800 ”	223 ”	223			Sold at Ramnagar and in native Gurhwal.
B. Nagpúr	Jugtolí	”	”	250	150 ”	...	10 ”	...			Sold in the neighbourhood.
Ditto	Búkunda	”	”	150	80 ”	...	6 ”	...			
Ditto	Gooleth	”	”	80	60 ”	...	4 ”	...			
M. Nagpúr	Hat Jaisal	”	”	110	3 ”	4 ”	1 ”	...			Sold within the Puttí.
Painu	Chulya	”	By digging earth.	184	3 ”	12 ”	...	...			Ditto ditto.
Jériakote	Dandatolí	”	”	150	25 ”	16 ”	8 ”	...			Ditto ditto.

GURHWAL;
SENIOR ASSTT. COMMR.'S OFFICE,
CAMP ALMORAH,
The 3rd April 1869.

(Signed) C. J. GARSTIN,
Offg. Senior Asstt. Commissioner.

Captain Garstin, in submitting the numerical return from Gurhwal, says—

"The return has been prepared from statements sent in by Putwarees, and I do not think any great reliance can be placed on their correctness, as it must have been most difficult for them to find out the information required; the people working the mines themselves not having the slightest idea of the amount of ore they either collect or sell.

"The copper mines in Dhánpur used formerly to bring in a much larger revenue than they now do; the fact being that the shafts have been sunk so deep into the hill, and the passages are so intricate, that very few people will venture into them. The miners also say, that the mines are nearly worked out.

"There is, one may say, no export of ores from this district, the mines worked only being sufficient to supply the wants of the people.

"I regret that I cannot give further information, but the agency at my disposal is too limited to enable me to collate any that I would deem trustworthy."

1st July 1869. A. W. LAWDER.

The mines noticed in the above return have been known for many years. Some of them were noticed by the earliest European visitors to these hills. And when there was no communication with other countries and no supply of imported metal, they were naturally of higher importance and of greater value than in later years, when their rudely extracted products have had to contend with European manufactures. The earliest description, *in any detail*, of these sources of mineral wealth was given by Captain J. D. Herbert in 1829 in his report on the mineral productions of that part of the Himalaya mountains between the Sutlej and Káli (Gágra) rivers, &c. (Asiatic Researches, xviii, Pt. 1, 227). In this almost every locality noted above is mentioned. Dhánpur and Dhobrí at that time paid a revenue or royalty for the right of working of Rs. 1,200 per annum; Gangúli and Síra of Rs. 1,000; Pokri Rs. 600. The localities, modes of working, and rocks are described, and the means of improvement noted. The iron and lead mines are also noticed, as well as the non-metallic products of the hills—sulphur, alum, bitumen, graphite, borax, limestone, &c., &c. The inaccessibility of the various places is also noticed.

In 1838 a report on the copper mines of Kumaon by Captain H. Drummond appeared in the Journal of the Asiatic Society of Bengal (vol. vii, p. 934). In this he gives the results of an examination of many of the mines by a practical Cornish miner, Mr. Wilkin, whom he had brought out from England. The Rye (Rai) and the Sheera (Síra) mines, both noticed above, are specially referred to. Mr. Wilkin recommended certain trials and improvements in the mode of working, taking a favorable view of the prospects. An experimental trial was then made with the view of opening a regular mine at Pokri, in Gurhwal. Extensive workings had here been carried on from very early times, and one mine, called the Rajah Khán or Rajah's mine, had, it is said, yielded in one year more than Rs. 50,000. At the time alluded to (1838-39) the right of mining was leased for Rs. 100 per annum. Two galleries or adits were commenced, one in each of the two ravines in which the copper was known to occur, the Rajah Khán and the Chumitti ravines, about 500 yards apart. Up to May 1839, 149½ feet had been opened in the Rajah Khán drift, and 111 feet in the other. (Lieutenant Glasfurd, On the experimental copper mine in Kumaon, Jour. Asiat. Soc., Beng., viii., 471).

The work was continued until June 1841, when the estimated cost had been largely exceeded, and as no sufficient returns were obtained, the trial was finally stopped. At that time 257½ fathoms of ground had been driven through. In addition to the two old mines noticed above, the Rajah's and Chumitti (or Chaomuttee), a new opening was made, when good specimens of ore were found near the surface, but at a depth of 15 fathoms they ceased, and at 23½ fathoms it was abandoned. Details are given by Mr. Wilkin as to other mines in the neighbourhood of Pokri also.

The total sum expended in this experimental trial was Rs. 7,384 and there was realized by sale of copper during the time Rs. 779½. Mr. Lushington, who gives these details, mentions the real obstacles to success which have to be contended with. The distance of the mines from the plains, the slowness and expense of carriage, the cheapness and abundance of English copper, the superficiality of the mines yet known, and the want of coal are all serious drawbacks.

At the time Mr. Lushington wrote (1843) the mines of Dhânpur were rented for Rs. 1,700 per annum in 1812. Under the Ghoorka Government, the rent fixed for mines for the whole province was only Rs. 3,500 (Company's Rupees). Since 1815, when Kumaon was conquered by the British, up to 1846, the *average* revenue derived by the British Government was for copper in Kumaon Rs. 800 to 1,200, in Gurhwal Rs. 2,086, the highest revenue for any year, for all mines being Rs. 5,417. Iron yielded an average of Rs. 1,900 in Kumaon, and Rs. 226 in Gurhwal. (Account of experiment at Khotree copper mine, with notices of other copper mines, by G. S. Lushington, Esq., Commissioner, (Jour. Asiat. Soc., Beng., xii., 453).

Again, in September 1845, Mr. Sigismund Reckendorf, Mining Engineer, reported on the same mines, (Jour. Asiat. Soc., Beng., xiv, 471). Dhânpur and Pokri are on opposite sides of the Douliganga, each about six miles from the river, or 12 miles apart. Dhânpur is 1,000 to 1,500 feet higher than Pokri. Both are said to be on the same layer of talcose slate, which is stated to head north-15°-west. Mr. Reckendorf thinks, indeed, that the whole of the known copper mines from the Nepal terai on the east to beyond the Pokri mine on the west are only parts of one layer of no great thickness, sub-divided occasionally into two or three! He considers the ore not to occur in a regular lode or vein, but in a bed. He thought all previous trials had been misdirected, as they had been carried out in the old workings, and that new ground altogether ought to be opened up. He formed a much poorer idea of the chances of success at Dhobri, but considered that everything tended to show that at Pokri copper could be obtained in large quantity. He urgently deprecates, however, Government attempting anything itself.

In 1854 the Hon'ble Court of Directors sent out Mr. W. Jory Henwood, with two mining assistants and an iron smelter, to examine and report on the metalliferous deposits of Kumaon and Gurhwal. After going over all the districts, Mr. Henwood reported in May, 1855. This report gives much useful information, but, so far as regards the copper mines, the opinion formed was most unfavorable, and indeed condemnatory. Speaking of Pokri he says: "We have never before seen a spot so scantily sprinkled with ore, and offering, in our judgment, so small a prospect of improvement so extensively and perseveringly worked." (Selections from Records of Government of India, Home Department, viii, p. 5). The greater part of the report is devoted to the rich iron deposits of these hills, regarding which we cannot at present speak.

Subsequently to this (1855) I know of no systematic attempt to work the copper mines of Kumaon or Gurhwal. The native miners have, however, continued to delve out annually in a wretchedly insecure way a few hundred maunds of ores, an amount which, from Mr. Lawder's returns given above, appears to be more considerable than I should have expected.

The Geological Survey has not yet had an opportunity of visiting these hills.

October, 1869. T. OLDHAM.

COAL-FIELD NEAR CHANDA, CENTRAL PROVINCES.

Since the first notice of this field was published in the Records of the Geological Survey (August 1868, p. 23), a systematic examination of the field has been commenced. It was fully pointed out by Mr. W. Blanford, in the paper referred to, that the country was in parts so covered that it would be impossible to obtain any satisfactory knowledge of its structure without boring or sinking. Since then two skilled borers and boring tools have been obtained from England, and further sets of tools are on their way. The season had already far advanced before these were available, and as the rains were then near at hand, it was considered desirable that these men who had just arrived, and who were therefore quite unacquainted with the peculiarities of life in this country and of the climate in which they were to work, should, for a time at least, be kept where good house shelter could be obtained. The work was placed under the immediate charge of Mr. M. Fryar, M. E., Mining Assistant on the Geological Survey. And he was requested to select spots for boring within reach of Chanda or Ballarpur during the rainy season and to keep the men at first together, so that they could aid one another in any difficulty which might occur at first starting.

Under Mr. Fryar's instructions the first bore-hole was commenced in the beginning of June. This bore-hole (No. 1) was very near the south-east corner of the boundary of the Nuggeena Bagh, north of the native town of Chanda. This bore was put down 80 feet and was then stopped, "as the material bored through continued to be simply stiff sand." A second bore was then commenced about 230 feet from the first, in the direction of the dip of the rocks,—about east-15°-north. This passed through the following section:—

Feet.	Inches.	
12	0	Of ochrey arenaceous shale.
8	0	Soft shale of deep red and purple colour.
20	0	Of the same material as found in No. 1 bore-hole.
Total ... 40	0	

At this depth, 40 feet, this bore-hole was also stopped.

No. 3 was then commenced at about 450 yards still further in the direction of the dip, or into the field, or about 527 yards from No. 1. This bore-hole was near the junction of the Ghimoor road and the Nagpur road, its bearing from No. 1 (magnetic) being about north-38°-east.

This third boring gave the following section:—

Feet.	Inches.	
5	0	Brown soil.
11	0	Red brongel.
3	0	Brown sand.
1	0	Hard red ironstone.
17	0	Light pipe clay.
2	0	Dark brown clay.
12	0	Soft light sandstone.
3	0	Light brown sandstone.
10	0	Light colored sandstone.
7	0	Very light colored sandstone, very coarse.
2	0	Yellow sandstone.
4	0	Very dark sandy shale.
25	0	Variegated sandstone.
10	0	Yellow sandstone.
11	0	Brown sandstone.
9	0	Variegated sandstone.
1	0	Coarse brown sand.
25	0	Variegated sandstone.
2	0	Light blue sandy shale.
2	0	Good *coal (a).*
12	0	Very dark blue shale, a little sandy.
7	0	Light blue sandstone, a little shaly.
24	0	Light colored sandstone.
1	6	Black shale mixed with *coal (b).*
16	0	Light blue sandstone.
1	0	Dark sandy shale.
0	6	Iron pyrites.
18	0	Light blue sandstone and brown sand mixed.
Total ... 242	0	

"And as in this depth we have entered something of a Talchir appearance, I have stopped this hole and commenced one at Ballarpur." (Mr. Fryar's report, 24th July).

Specimens of the *coals* passed through in this pit, as brought up by the pump, were assayed, and yielded—

	Carbon.	Volatile.	Ash.
(a) two feet bed	47·8	41·0	11·2
(b) eighteen inch bed...	42·7	41·2	16·1

both poor coals, neither containing 50 per cent. of carbon. The beds are also from their small thickness unworkable with profit at that depth.

A fourth boring was made near the dâk bungalow to the west by south, and between the bungalow and the Jhurput nala. This (No. 4) was put down with small rods, "and ought to have entered coal a few feet from the surface, if the apparent dip of rocks at the surface had been a guide approximately to the dip of the coal beds below." (Mr. Fryar, 28th July). This boring was about 500 feet to the west of one put down by Mr. Binnie, C. E., in which coal was said to have been cut. No. 4 did not reach coal, and was abandoned.

Preparations were made for a fifth boring (No. 5) about six chains from the Jhurput nala on the left bank, due south of the town of Chanda, but no boring was carried out here.

At Ballarpur, the first boring alluded to above was put down on the left bank of the river, nearly opposite the point where coal is seen on the right or Hydrabad side of the river, and about 300 feet from the river bank. This position was injudiciously selected, as proved to be the case. It was in fact within the limits of the old bed of the river, and was abandoned, as there was not tubing "enough to carry the hole through the running sand and gravel met with." This difficulty might certainly have been avoided, but unfortunately it was not. The probability was in fact pointed out in April 1867 (see p. 25, Records, Geological Survey of India, 1868), where it is said, "in sinking upon the Chanda side, it is far from improbable that only alluvial clay may be met to the depth mentioned." The boring tools were then shifted to a second position where rocks were visible close by. This second hole was put down about a mile to the north-east near the town of Ballarpur (less than half a mile). This boring was carried down to a total depth of 236 feet.

The following is the section passed through :—

	Feet.	Inches.	
		0	Red iron brongel (moorum).
	6	0	Soft brown sandstone.
	9	0	Strong blue clay.
	2	0	Very dark-red sandstone mixed with iron.
	10	0	Brown sandstone.
	30	0	Soft light colored sandstone.
	12	0	Variegated sandstone.
	1	0	Red sandy clay.
	6	0	Dark colored sandstone.
	3	0	Brown sandstone.
	1	0	Hard red sandstone mixed with iron.
	10	0	Brown sandstone, with mica.
	16	0	Yellow sandstone.
	0	9	Good *coal.*
	0	9	Black shale.
	1	6	Good *coal.*
	2	0	Very dark shale.
	3	0	Green looking sandstone (blueish).
	10	0	Dark-blue sandstone mixed with shale.
	26	0	Light colored sandstone.
	0	9	Iron pyrites.
	26	0	Light colored sandstone.
	2	10	Black shale, a little coaly.
	10	0	Dark blue sandstone mixed with shale.
	26	0	Light colored sandstone.
	0	9	Iron pyrites.
	0	9	Light colored sandstone.
	3	0	Black shale, a little coaly.
	11	6	Dark colored sandstone, a little shaly.
	1	6	Iron pyrites.
	1	6	Light colored sandstone.
Total ...	236	7	

Mr. Fryar reported on the 16th September that he had ordered this hole to be stopped, "as we are evidently in the Talchir sandstones." He adds, 'you will observe a similarity of section by comparing the second hole at Ballarpur with the No. 3 one at Chanda' (given above). There is doubtless some little similarity, but I am unable to see the proof that the bore was evidently in the Talchir beds.

The boring rods were then moved from Ballarpur to a point on the road to Moolk from Chanda, between two and three miles from Chanda town, near the place where the road crosses the Jhurput nala, in the corner between the stream and the road to the south of the road. This boring was in progress up to date of last report, and on the 12th instant had reached a total depth of 124 feet 6 inches. The following is the section :—

	Feet.	Inches.	
	5	0	Loose sand and loamy soil.
	6	8	Yellow sandstone and bands of ironstone.
	1	3	Hard red ironstone.
	7	0	Variegated sandstone, with little clay.
	11	0	Soft red ironstone.
	0	6	Ironstone band.
	8	0	Red sandstone mixed with iron.
	4	0	Yellow sandstone.
	11	0	Variegated sandstone.
	1	10	Yellow sandstone.
	0	8	Very hard red rock.
	7	6	Brown sandstone.
	28	0	Light brown sandstone.
	9	0	Light red sandstone.
	1	0	Coarse light brown sandstone.
	2	6	Hard red rocks.
	20	0	Variegated sandstone.
Total ...	124	6	

It is evident that the rods have not yet touched a bed of the coal-bearing rocks in this section, all the beds passed through belonging to the Upper or Panchet series.

Reviewing the results thus obtained, we find that borings at Chanda, which are represented as having passed through the entire thickness of the coal-bearing rocks there, and to have pierced the Talchir beds below, (in which no coal is known), exposed only two thin beds of poor coal, so thin as to be unworkable. While at Ballarpur also, a boring of about the same depth (about 240 feet), said in like manner to have gone through the entire thickness of the coal-bearing rocks and to have pierced the Talchirs, showed also two beds of coal, one of 18 inches, one of 9 inches in thickness.

It need scarcely be said that none of these are workable at the depth at which they occur.

Before these explorations had commenced, Major Lucie Smith, Deputy Commissioner of Chanda, who deserves the highest credit for the sustained zeal and intelligent earnestness with which he has prosecuted these enquiries, had a pit opened on the bed of coal visible in the Wurda channel, near Googoos, or Chendoor. And from the coal there met with, at a depth of 30 feet below the surface, a considerable quantity was raised for experimental trials to which I will presently refer. As, however, this pit was within the limits of the ordinary flood level of the Wurda, a bore-hole was put down about 330 yards from the bank of the river and nearly in the line of strike of the beds. This bore-hole was carried out by Corporal Carson, of the Public Works Department, under the orders of Major Lucie Smith, Mr. Fryar also assisting. As was tolerably certain at such a distance the coal was found to continue. This bore-hole was sunk altogether to 121 feet 6 inches, and gave the following section :—

	Feet.	Inches.	
	3	0	Surface clay.
	5	0	Red moorum.
	40	0	Variegated sandstone.
	8	0	White sandstone.
	6	0	Yellow clay.
	10	0	Dark-brown clay.
	2	0	Black shale.
	3	0	*Coal.*
	3	0	Dark sandy shale.
	3	0	*Coal.*
	5	6	Blue shale.
	12	0	*Coal.*
	4	0	" mixed with iron pyrites.
	5	0	*Coal.*
	0	6	Shale.
	11	6	*Coal.*
Total ...	121	6	

Below this is white sandstone streaked with black shale. It is much to be regretted that the boring was not continued, so as to ascertain the thickness of the formation here and the position of this thick deposit of coal in it.

The coal having thus been proved here, a pit was commenced and is now in progress.

A second bore-hole was then commenced about a mile to the south, and to the west a little south of the village of Googoos. This is as nearly as can be the locality recommended by the Geological Survey in 1867, "about 300 yards west of the village of Googoos." This bore-hole was carried down in all about 112 feet, giving the following section :—

	Feet.	Inches.	
	6	0	Surface clay.
	22	0	Variegated sandstone.
	0	3	Ironstone.
	21	6	Variegated sandstone.
	2	6	Red rock.
	4	0	Yellow clay.
	6	0	Dark shaly clay.
	3	6	Shale.
	2	0	Crimson colored sandstone.
	17	0	Clay and sand.
	20	0	Light colored sandstone.
	7	0	Variegated sandstone.
Total ...	111	9	

At this depth the mineral lifter jammed, and after several days' unavailing efforts to lift it, it became evident that it would be necessary to sink to it, in order to relieve the tools. After some delay this sinking is now in progress and had reached 27 feet on the 12th instant.

Such is the progress made in the exploration of the field.

As regards the important question of the quality of the coal, several trials have been made. The coal raised from the pit near Googoos was first sent to the Great Indian Peninsular Railway for trial in their locomotives. The Locomotive Superintendent reported on the 16th April "that the coal was not suitable for locomotive purposes, being very dirty. Out of 1 ton 4 cwt. used, there were 6 cwt. of clinker, but very little in the smoke-box, with a load of 4 cotton wagons and one brake. Great quantities of sparks came out from the chimney, and remained on fire for some time. From Boorhanpore to Khundwa, the brake-van alone was attached to the engine, and although the fire had been cleaned at Chandnee station, it had to be cleaned again before getting to Dongergaon (17 miles). We could not get a welding heat with the coal, although it contains great quantities of gas."

The fire-boxes on the Great Indian Peninsular Railway are constructed to suit English coal, and the engineers are accustomed to its use. There appeared, therefore, sound reason for not admitting this to be a conclusive trial. More coal was raised, and better coal selected, and this was sent to the East Indian Railway at Jubbulpore, some to the works in progress under the Public Works Department at the Kanhan bridge, and also a second supply to the Great Indian Peninsular Railway. The results of these trials are decidedly encouraging. It is said that the coal took the train on the Great Indian Peninsular Railway down as far as Budnaira (100 miles) without difficulty; the engineers were agreeably surprised with its capabilities, but did not "think it quite up to the mark." At the Kanhan bridge works, it was tested in a small portable engine. "With Chanda coal steam was got up in 1 hour and 25 minutes with a consumption of 36lbs., the coal being wet, a strong breeze blowing and rain falling at the time. The coal burnt clear, and freely and very clean, leaving a small residue of gray ash without clinkers, and evaporated on the average 4lbs. of water per 1lb. of coal consumed. With English coal steam was raised in 1 hour 35 minutes, with a consumption of 28lbs., the coal being drier, but small and deteriorated from exposure, but the weather was fine at this part of the day and very little wind. The evaporation was at the rate of 6·5lbs. of water per 1lb. of coal." The Chanda coal is specially noted as "burning clean."

The trial on the East Indian Railway was the only one in which the Chanda coal was compared with other Indian coal. "The Locomotive Superintendent reports that the consumption of Chanda coal on two trials was 88¾ cwts. and 85 cwts. per 100 miles, against 67 cwts. of Ranigunj coal for the same distance. The coal did not work well at first, partly, it appears, owing to the construction of the fire-boxes, and partly, perhaps, to the stormy weather in which one of the trials was made, but it did better afterwards."

These trials show the 'duty' of the coal to be as compared with English coal ('small and deteriorated by exposure') as 4 : 6·5, or 61 per cent., or, in other words, it is ⅖ths worse than this English coal.

As compared with Ranigunj coal, its duty was as 67 to 87 (mean of 88·75 and 85·), or 77 per cent., or nearly ¼th worse. It is not stated what "Ranigunj" coal was in use.

The coal, however, did the work required of it, and in a satisfactory manner.

These coals were, as mentioned, from the pit sunk at the Wurdah. To test the coal met in the boring near that river, as given above, Mr. Fryar was requested to forward specimens. Of these he sent 33, one from each of the three-feet seams above the thick coal and 31 from it, these being taken from the material brought up by the pump at intervals of about a foot of sinking. These were all assayed carefully by Mr. Tween, and the results are given below.

There can be no doubt that assays of this kind, and more especially when made on the stuff broken down by a boring-chisel, are only approximate indices to the value of the coals tested. But in the absence of better means, they do afford fairly comparable results, and do unquestionably give a fair indication of the economical value of the coals. Indeed, the very results given above are singularly confirmatory of this. The assays were completed for several weeks before the above results of actual trials were received.

The 33 specimens tested gave the following results:—

Depths, &c.	Carbon.	Volatile.	Ash.	Depths, &c.	Carbon.	Volatile.	Ash.
A (1st three-feet seam) ...	46·9	44·0	9·1	16	38·5	36·7	24·8
B (2nd three-feet seam) ...	37·4	28·0	34·6	17	44·2	31·4	24·4
1 (from thick coal)	48·0	36·6	15·4	18	29·3	23·5	47·2
2	45·5	36·4	18·1	19	36·8	33·0	30·2
3	44·0	39·4	16·6	20	43·0	39·6	17·4
4	43·5	40·0	16·5	21	46·3	41·1	12·6
5	44·4	39·8	15·8	21*	44·9	42·5	12·6
6	44·7	39·5	15·8	22	42·7	30·6	26·7
7	47·4	36·8	15·8	23	45·3	33·0	21·7
8	47·7	36·8	15·5	24	52·4	32·0	15·6
9	47·6	40·0	12·4	25	40·3	24·5	35·2
10	48·2	39·8	12·0	26	45·6	32·8	21·6
11	46·6	44·6	8·8	27	44·2	29·0	26·8
12	40·7	44·5	14·8	28	55·1	32·0	12·9
13	60·4	[illegible]	6·6	29	35·6	32·8	31·6
14	38·3	28·1	33·6	30	56·2	31·6	12·2
15	37·8	28·8	33·4				

It is obvious from these results that while this thick deposit contains some layers which are really good coal, there is also a large amount which is scarcely deserving of the name of coal at all. Stuff with 30 and 40 and even up to 47 per cent. of ash—useless matter—would be of no avail excepting for purely local demand in such work as lime-burning, &c., while coal such as is represented by No. 13 or No. 30, or the bed A, would hold just comparison with some of the best coals in India. Probably the fairest way, seeing that although the specimens are taken from about every foot, the actual matter assayed may really represent only an inch or two in thickness, is to take the whole as one, and take as the mean composition the average of all the results (neglecting for the present the two separate 3 feet seams). And for comparison, to take 30 specimens of Ranigunj coals from different worked beds, and take the average composition of these.

Taking the 31 specimens of the Googoos coal, the average result of all is—

Carbon	44·51
Volatile	35·34
Ash	20·15

And the average result of 30 Ranigunj coals is—

Carbon	50·9
Volatile	34·6
Ash	14·5

that is, the Googoos (average) coal is 6·39 per cent. inferior to the *average* of Ranigunj coals as to the main heating power, and it is also 6 per cent. worse than the same as to amount of useless matter. Or, viewing it in another way, it may be said that out of the 31 odd feet of 'coal' there are 28, which contain less carbon than the *average* of 30 Ranigunj coals, good and bad, and only 3 which contain more; while there are 23 which contain more ash than the same average, and only 8 which contain less.

These results appear unquestionable, so far as the coal yet obtained is concerned. That this coal will at the same time prove highly useful cannot for a moment be questioned; and we must only continue to seek for better.

The results of these trials showed the duty of Chanda coal roughly, as compared with Ranigunj coal, to be as 67 to 87. The comparison by assay gives 45 : 51, or the trial by rail gives the work in the ratio of 1·00 : 1·29, that by assay as 1·00 : 1·14. As compared with English coal the duty was by actual trial as 4·0 to 6·5, by assay as 44·5 : 68, or, in the first case, as 1 : 1·63, in the latter as 1 : 1·53.

These are very close approximations and fully bear out the value of such assays. In all cases, it is worth notice also, the result as per assay is more favorable than that by actual trial. Both methods of testing the value prove that good useful fuel exists near Googoos in considerable quantity.

The explorations are being carried on with vigour, and the results will be given from time to time.

In connection with this enquiry, it is necessary to give publicity here to some important facts regarding which considerable misapprehension has evidently existed. In the last general report on the Central Provinces, the Chief Commissioner has (p. 76) said: 'so far coal has only been discovered in that known as the Damuda series, and it remains to be proved whether the Kamptee group is carboniferous.' This name 'Kamptee group' has never been published before or defined, and without such definition it is meaningless. It was a term used by Mr. W. Blanford on a preliminary sketch map of the district, copy of which was given to the officer of the Geological Survey working at Chanda for his information. But the term was simply one of convenience, and for temporary local use as applied to a series of beds in the vicinity, and signifying nothing more than those local beds; simply a name used instead of a long phrase to convey certain peculiarities in texture, &c. It is one of many such short names which, used for a time merely locally, give place to others when relations and connections have been traced out. It has therefore never been published or used in any other way than as a term of convenience among the officers of the Geological Department. It is in fact meaningless without definition.

But having thus been used, I may state that the local beds so called "Kamptee" are nothing more nor less than the Central Indian representatives of the great *Panchet* series of rocks, so well seen in the Raniguuj coal-field, still better developed in the Jherria, the Bokaro, the Karunpura, and other detached coal-fields towards the west, and which series of rocks can be (and have been) traced across all the intervening country up to Nagpur and Chanda. And as in the Raniguuj field, so in every other section exposed throughout the hundreds of miles of country (thousands of square miles) not a trace of coal is known to occur in them. This induction is far wider and far more satisfactory than any examination of the Central Provinces alone could afford.

But, in addition to this, accompanying this extension and development of the Panchet series, there is, from east to west, a steady and continuous but rather rapid diminution of the true coal-bearing rocks (the *Damuda* series), so that the formation which in the east is of several thousand feet in thickness, with more than one hundred beds of coal of varying thickness, and which is there easily divisible into three groups, on passing to the west so dwindles down, that, in the Nerbudda valley and in the Chanda field, the total thickness of the formation does not exceed as many hundred feet as it was thousands in the east, and that all the coal is confined to a few beds of great irregularity near the base of the series. These facts also have been established not by any local investigation, but by a long continued and systematically carried out series of examinations and measurements spread over hundreds of miles of the country.

There appears not a doubt as to the fact that coal does not occur in the Panchet rocks. There is equally no doubt that coal is not in the Talchir rocks below, and the simple point that remains to be proved in the Chanda field is the extent, thickness, and value of the coal which does accompany the Damuda rocks. If the country were not so much covered the limits of these rocks could readily be traced; there is no difficulty in distinguishing them. But unfortunately there is a large part so concealed by superficial deposits that the existence of these coal-bearing rocks must be probed out by boring. And this is what is now being done by the Geological Survey for the Government of India.

The borings at Chanda and at Ballarpur given above are additional proofs of the very limited thickness of these rocks. The entire thickness of the Damuda series, as it there exists, together with all the overlying beds, is said to have been passed through within about 235 feet. Of this more than one-third belongs to the upper series, leaving the thickness of the entire Damuda or coal-bearing formation here not more than about 150 feet!

The 18th October 1869. T. OLDHAM.

LEAD *in the* RAIPUR *District:* CENTRAL PROVINCES.—To the information already given regarding this lode of lead-ore but little has been added since then (*see* Records, Geological Survey of India, 1862, Pt. 2, p. 37). At the close of the season, Mr. Smart, the Revenue Surveyor engaged in that district, completed a small plan of the locality and immediate vicinity on a scale of four inches to the mile. He found fragments of the metallic vein scattered upon the top of the hill, on which it was seen for a distance of half a mile from the spot where it was discovered last year. 'The direction of dip of the vein could not be ascertained owing to the confused and fractured arrangement of the surface rocks.' Mr. Smart had no means of proving the vein.

I hope to be able to have the locality examined this season.—T. O.

METEORITES.—To the kindness of Dr. Waldie we are indebted for the remaining portion of the specimen of the Khetree stone, (fell February 1867), which he analysed with care, and of which he gave an excellent description at the meeting of the Asiatic Society in June 1869. Dr. Waldie states how it is frequently so difficult to procure specimens of these highly interesting bodies which fall from the heavens, as the people, in their ignorance looking upon such visitors as evidence of the wrath of their deities, carefully reduce to powder and dissipate all the pieces which they can procure. Only two pieces are known to exist, both small; one is in the collection of the Asiatic Society, and this one in the collection of the Geological Survey.

From Dr. Tschermak, the successor of the much regretted Dr. Moritz Hörnes, in charge of the Imperial Mineral Cabinet at Vienna, we have also received a very good specimen of the fall which occurred at Slavetiĉ, in Croatia, on the 22nd May, 1868, and described by the indefatigable Haidinger, on the 3rd December, 1868, to the Academy of Sciences, Vienna.

Also, a specimen of the Ornans (Doub) fall, of which we were already in possession of a fine piece through the good offices of M. Marcou, (see Records, Geological Survey of India, February, 1869). This fall took place on 11th July, 1868.

Also, a specimen of the very interesting stone which fell at Krähenberg near Zweibrücken (Pfalz) on the 5th May, 1869.

These valuable additions to our numerous collection are further proofs of the friendly aid and co-operation we have invariably experienced from the Geologists of Austria.

October, 1869. T. OLDHAM.

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BEAUMONT, ELIE DE.—Rapport sur les progrès de la stratigraphie. Recueil de Rapports sur l'état des lettres et les progrès des sciences en France, Roy. 8vo., Paris, 1869.

BENECKE, DR. E. W.—Geognostisch-Palæontologische Beiträge, Vol. II, Part 2, Roy. 8vo., Münich, 1869.

BENEDEN, VAN, AND GERVAIS, PAUL.—Ostéographie des Cétacés vivants et Fossiles, Parts 2, 3, 4 (with Plates), 4to., Paris.

BERNARDI, LE CHEVALIER, A. C.—Monographie des genres *Galatea* et *Fischeria*, 4to., Paris, 1860.

BRAUNS, DR. D.—Der mittlere Jura im nordwestlichen Deutschland, 8vo., Cassel, 1869.

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Titles of Books. *Donors.*

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EICHWALD, E.—Lethaea Rossica, ou Paléontologie de la Russie, Part 12, with Atlas, 8vo., Stuttgart, 1869.

GERVAIS, PAUL.—Zoologie et Paléontologie générales, Parts 10 and 11, 4to., Paris, 1869.

HACKETT, T. R.—Geological and Mining Report of the Gympie Gold Field, Fcp., Gympie, 1869. THE AUTHOR.

HAUGHTON, REV. S.—The Three Kingdoms of Nature briefly described, 8vo., London, 1868.

HAUGHTON, REV. S.—On some elementary principles in Animal Mechanics (From the Proceedings of the Royal Society, No. 94), 8vo., London, 1869 (Pamphlet). THE AUTHOR.

KARSTEN, DR. GUSTAV.—Beiträge zur Landeskunde der Herzogthümer, Schleswig und Holstein, II, Reihe, Heft 1, 4to., Keil., 1869.

LARTET, E., AND CHRISTY, H.—Reliquiae Aquitanicae, Parts 8, 9, 4to., London, 1869.

LINDEMAN, MORITZ.—Die arktische Fischerie der Deutschen Seestädte, 1620—1868. Petermann's Geographische Mittheilungen, Supplement, No. 26, 4to., Gotha, 1869.

LOTTNER, BERGRATH HEINR.—Leitfaden zur Bergbaukunde, Band II, Part 2, 8vo., Berlin, 1869.

MARSH, G. P.—Man and Nature; or, Physical Geography as modified by Human Action, 8vo., London, 1864.

MARTINI UND CHEMNITZ.—Systematisches Conchylien-Cabinet, Lief., 190, 191, 4to., Nürnberg, 1869.

MASTERS, M. T.—Vegetable Teratology (Published by Ray Soc., London), 8vo., London, 1869.

MUIR, J.—Original Sanskrit Texts on the Origin and History of the People of India, their Religion and Institutions, Vol. III, 8vo., London, 1868. GOVT. OF INDIA.

NEILREICH, DR. A.—Diagnosen der in Ungarn und Slavonien bisher beobachteten Gefässpflanzen, 8vo., Wien, 1867. (Published by K. K. Zool. Bot. Gesellsch., Wien).

ODLING, WILLIAM.—A course of six lectures on the chemical changes of Carbon, 12mo., London, 1869.

OOSTER, W. A., UND F. VON C.—Protozoe Helvetica, Mittheilungen aus dem Berner Museum der Naturgeschichte, &c., I, 4to., Bern, 1869.

PAGE, DR. DAVID.—Chips and Chapters, a book for Amateur and Young Geologists, 8vo., London, 1869.

PFEIFFER, DR. L.—Malakozoologische Blætter, Vol. XVI, 3—8 Bog., 8vo., Cassel, 1869.

PICTET, F. J.—Matériaux pour la Paléontologie Suisse ou recueil de monographies sur les fossiles du Jura et des Alpes, 4th Series, Parts 10, 11, 4to., Geneva, 1868.

QUENSTEDT, F. A.—Petrefactenkunde Deutschlands, 1st Division, Vol. II, Parts 2, 3, with Atlas, 8vo., Leipzig, 1869.

ROSCOE, H. E.—Spectrum Analysis, 8vo., London, 1869.

SCHUMANN, J.—Die Diatomen der hohen Tatra, 8vo., Wien, 1867. (Published by K. K. Zool. Bot. Gesellsch., Wien).

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Titles of Books. *Donors.*

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WINNERTZ, JOH.—Beiträge zu einer Monographie der Sciarien, 8vo., Wien, 1867. (Published by K. K. Zool. Bot. Gesells, Wien).

PERIODICALS.

American Journal of Conchology, Vol. IV, Part 5, 8vo., Philadelphia, 1869.

American Journal of Science and Arts, 2nd Series, Vol. XLVII, No. 141, 8vo., New Haven, 1869.

Annals of Indian Administration in the year 1867-68, Vol. XIII, Part 1, 8vo., Serampore, 1868. THE GOVT. OF INDIA.

Annals and Magazine of Natural History, &c., 4th Series, Vol. III, Nos. 17, 18, Vol. IV, Nos. 19, 20, 8vo., London, 1869.

Engineers' Journal, New Series, Vol. XII, Nos. 19—21, 4to., Calcutta, 1869.

Geological Magazine, Vol. VI, Nos. 59, 62, 8vo., London, 1869.

Journal de Conchyliologie, 3rd Series, Vol. IX, No. 3, 8vo., Paris, 1869.

Neues Jahrbuch für Mineralogie, Geologie und Palæontologie, Parts 3, 4, 5, 1869, 8vo., Stuttgart, 1869.

Novitates Conchologicae, I Abth., 34 Lief., 4to., Cassel, 1869.

Novitates Conchologicae, II Abth., 14 Lief., 4to., Cassel, 1869.

Palæontographica, Vol. XVII, Part 2, 4to., Cassel, 1869.

PETERMANN, DR. A.—Geographische Mittheilungen, Heft. IV, V, VI, 1869, 4to., Gotha, 1869.

Professional Papers on Indian Engineering, Vol. VI, No. 24, Roy. 8vo., Roorkee, 1869. PRINCIPAL, THOMASON COLLEGE.

Quarterly Journal of Microscopical Science, New Series, No. XXXV, 8vo., London, 1869.

Quarterly Journal of Science, No. XXIII, 8vo., London. 1869.

Records of the Geological Survey of India, Vol. II, Part 3, 8vo., Calcutta, 1869. GEOLOGICAL SURVEY OF INDIA.

Revue universelle des mines, de la Métallurgie, des travaux publics, &c., Vols. XXV & XXVI, Nos. 1 & 2, livr., 8vo., Liege, 1869.

Zeitschrift für die gesammten Naturwissenschaften, Vol. XXXII, 8vo., Berlin, 1868. NAT. HIST. SOC., HALLE.

GOVERNMENT SELECTIONS, &c. (FROM THE GOVERNMENTS).

BENGAL.—General Report on Public Instruction in the Lower Provinces of the Bengal Presidency, 1867-68, with Resolution, 8vo., Calcutta, 1868. THE GOVERNMENT OF BENGAL.

" Report of the Meteorological Reporter to the Government of Bengal for the year 1868-69, with Meteorological Abstract for the year 1868, Fcp., Calcutta, 1869. THE GOVERNMENT OF BENGAL.

BOMBAY.—Official Correspondence relating to the System of Revenue Survey and Assessment and its administration in the Bombay Presidency, 8vo., Bombay, 1869. THE BOMBAY GOVERNMENT.

BRITISH BURMAH.—Report on Hospitals and Dispensaries for 1867-68: Extract from Proceedings in the Home Department, No. 263, Roy. 8vo., Maulmain, 1869. CHIEF COMMISSIONER OF BRITISH BURMAH.

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CHIEF COMMISSIONER OF CENTRAL PROVINCES.

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THE GOVERNMENT OF INDIA.

MADRAS.—Selections from the Records of the Madras Government, No. XI. Report on Public Instruction in the Madras Presidency for 1867-68, 8vo., Madras, 1868. THE MADRAS GOVERNMENT.

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MEDICAL DEPARTMENT.—A Sketch of the Medical History of the Native Army of Bengal for 1868, by Surgeon Major J. T. C. Ross, Foolsc., Calcutta, 1869.
INSPECTOR GENERAL OF HOSPITALS.

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THE GOVERNMENT, N. W. P.

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THE GOVERNMENT OF THE PUNJAB.

ROORKEE.—Thomason Civil Engineering College, Roorkee. Annual Examination, August, 1869. Report at the close of the session, 1868-69. Fcp., Roorkee, 1869. PRINCIPAL, THOMASON COLLEGE.

TRANSACTIONS OF SOCIETIES, &C.

BOMBAY.—Transactions of the Bombay Geographical Society, from January 1865 to December 1867, Vol. XVIII, 8vo., Bombay, 1868. THE SOCIETY.

CALCUTTA.—Journal of the Asiatic Society of Bengal, Vol. XXXVIII, Part II, No. 3, 8vo., Calcutta, 1869. THE SOCIETY.

„ Proceedings of the Asiatic Society of Bengal, Nos. 7, 8, 9, 8vo., Calcutta, 1869.
THE SOCIETY.

DUBLIN.—Journal of the Royal Geological Society of Ireland, Vol. II, Part 1, 8vo., Dublin, 1868. THE SOCIETY.

KŒNIGSBERG.—Schriften der Königlichen Physikalisch-Oekonomischen Gesellschaft zu Königsberg, IX, Abtheil, 2, 4to., Königsberg, 1868.

LONDON.—Journal of the Society of Arts and of the Institutions in Union, Vol. XVII, 856—871, 8vo., London, 1869. THE SOCIETY.

„ Journal of the Royal Geographical Society, Vol. XXXVIII, 8vo., London, 1868.
THE SOCIETY.

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THE SOCIETY.

" Memoirs of the Literary and Philosophical Society of Manchester, 3rd Series, Vol. III, 8vo., London, 1868. THE SOCIETY.

NORTHUMBERLAND.—Natural History Transactions of Northumberland and Durham, Vol. III, Part 1, 8vo., London, 1869.

PARIS.—Bulletin de la Société Géologique de France, 2nd Série, Vol. XXV, No. 5; Vol. XXVI, No. 2; 8vo., Paris, 1868. THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute, 3rd Series, Vol. LVII, Nos. 4, 5, 6, 8vo., Philadelphia, 1869. FRANKLIN INSTITUTE.

ST. PETERSBURG.—Bulletin de l' Academie impériale des Sciences de St. Petersbourg, Vol. XIII, Nos. 4, 5, 6, Vol. XIV, No. 1, 4to., St. Petersbourg, 1869.

TORONTO.—Canadian Journal of Science, Literature and History, New Series, Vol. XII, No. 2, 8vo., Toronto, 1869. CANADIAN INSTITUTE.

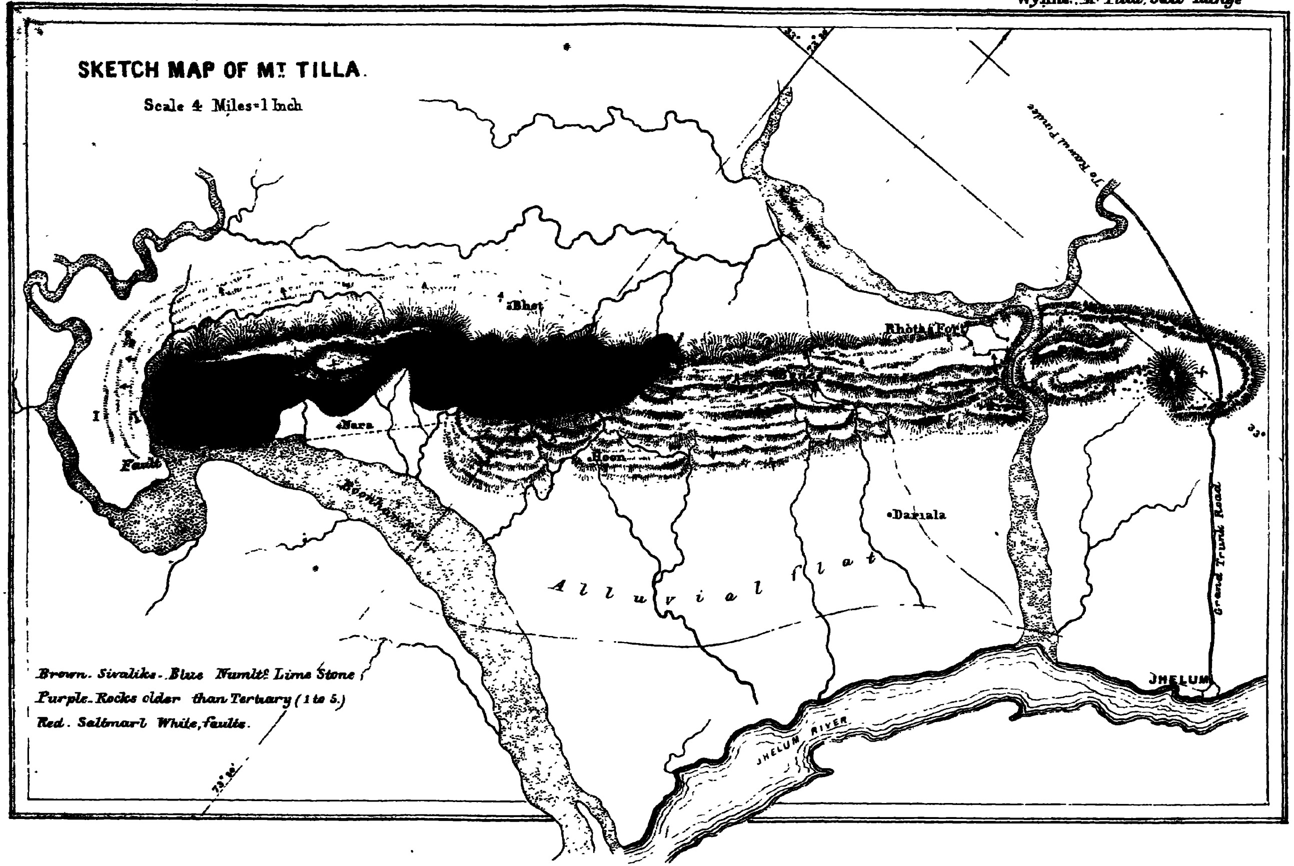
VIENNA.—Verhandlungen der K. K. Zoologisch-Botanischen Gesellschaft in Wien, Vol. XVII, 8vo., Wien, 1867.

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe, 1st Division, Vol. LVII, Parts 4, 5.
2nd Division, Vol. LVII, Parts 4, 5.

Vol. LVIII, Part 1; Roy. 8vo., Wien, 1868.
THE ACADEMY.

MAPS, &c.

HAUER, FRANZ RITT. VON.—Geologische Uebersichts-karte der oesterreichisch-ungarischen Monarchie, nach den Aufnahmen der K. K. Geologischen Reichsanstalt—Blatt. Nos. I und II, 8vo., Wien, 1869.


SKETCH MAP OF MT. TILLA.
Scale 4 Miles = 1 Inch
Bhet
Nara
Hoon
Fault
Rhotas Fort
Darıala
Alluvial flat
To Rawul Pindee
Grand Trunk Road
JHELUM
JHELUM RIVER
Brown. Sivaliks. Blue Numltc. Lime Stone
Purple. Rocks older than Tertiary (1 to 5.)
Red. Saltmarl White, faults.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 4.] 1870 **[November.**

On the Geology of Mount Tilla in the Punjab, by A. B. Wynne, F.G.S., Geological Survey of India.

The fine hill which forms the subject of this brief memoir rises between the eastern termination of the Salt Range proper and the outworks of the Western Himalaya where the river Jhelum emerges from them to traverse the vast plain of the *Five Rivers* which united in the Lower Indus (or Sind) reach the sea near Kurrachi.

It is one of three or four minor ranges, all of which form links more or less between the Himalaya and the Salt Range. Of these the parallel chain of the Bukrala Hills to the north seems to form the most continuous connexion; but Mount Tilla exceeds them all in height, reaching an elevation of 3,242 feet above the sea. It runs generally north-easterly by east, commences abruptly at its western end, and continues thence lofty for about ten miles, when it sinks rather suddenly into high ravine ground, with elevations of over 1,200 and 1,300 feet, for about twelve miles further, past the extensive ruined fortress of Rhotas. It terminates in low rounded hills a few miles beyond this point, projecting into the commencement of the alluvial plains of the river Jhelum. It is widest where most lofty, having a base of three miles, but the extension of the range to the eastward is on an average not less than two and half miles in width.

Neither the Mount Tilla range nor that of Bukrala to the north appear to have any strong relation to the drainage depressions of the country in their immediate vicinity, both of these ridges and the valley between being crossed by the usually dry or nearly dry courses of streams, occasionally powerful, as indicated by the depths of their gorges and great width of their sandy beds when the currents become slack. With the Jhelum, however, ordinary relations seem to exist after it has left the Himalaya; the direction of the Tilla range coinciding more or less with that of the river, and the ground falling generally towards the latter—except where one of the other chains or groups of hills intervenes—on the southern side of the ridge.

The existence of Mount Tilla as a striking feature of the country—that of Chambal to the south, of the Bukrala range to the north, and indeed perhaps of the whole Salt Range itself—is, through denudation, directly due to huge dislocation of the stratified rocks, placing certain of the beds of greater or less strength in abnormal contact with others possessing different degrees of resistance to disintegrating forces. The chief line of dislocation affecting Mount Tilla passes along its southern base, obliquely separating the lofty portion from the lower extension to the east, and is perhaps continuous westward, though concealed, to the great fracture lying in the bed of the Boonhar river, which separates the adjacent portion of the Chambal range from the western termination of Tilla, completely discordant dips occurring on each side of the here constricted channel.

As results of the forces, or of similar forces to those, which caused this and other fractures, the whole strata of the country have been subjected to violent contortion, one of the finest curves being the interrupted anticlinal formed by the strata of Mount Tilla itself and traceable round its western end nearly to the line of dislocation occupying the lower gorge of the Boonhar.*

* On one of the early days of last April a somewhat singular occurrence was observed from the higher parts of Mount Tilla. The day was warm and bright, and a very strong breeze blowing, so much so that traversing

The denuding agencies acting strongly upon the varying consistencies of the rocks of this country have not only produced dominant features coinciding with the principal contortions and dislocations, but in much more minute detail caused their stratification so to govern the forms of the ground that the minor contortions in many cases become plainly visible in the ornamental hill-shading upon the very excellent one-inch (to the mile) maps produced by the Topographical Survey. This is much most prominent in the soft tertiary rocks which form so much of the surrounding country stretching far into the outer Himalaya; and it is partly a consequence of the steepness of the angles at which the strata are inclined in various directions. A wide belt of these tertiary rocks is known to border much of the Western Himalaya. Those which underlie them in the hills between the Ganges and Ravee have also been ascertained and described by Mr. Medlicott in one of the Survey Memoirs. Westwards or north-westwards from the Ravee river this succession has not yet been clearly worked out, but what is known renders it probable that the geology of this part of the hills will be found a continuation of that to the south-east. The very interesting Salt Range also exposes rocks older than this tertiary series which have not hitherto been identified with the infra-tertiary rocks of the Himalaya range. These lower rocks of the Salt Range, however, exhibit local changes, going from east to west, chiefly by the admission of new zones and by increase or diminution of thickness, and present a marked absence of all metamorphic strata. Hence it becomes a fair inference that the formations inferior to those of the tertiary belt above alluded to, and the conditions which produced them, had very considerably altered within the large area indicated; and some knowledge of the region wherein the transition commences would be very desirable. This region cannot be yet pointed out, indeed it may very possibly be entirely concealed by the newer rocks; but Mount Tilla is one of the nearest known places to the Himalaya range where the rocks next beneath the tertiary belt appear, outside or within its limits, as these may be assumed. These lower rocks appear only at the top and southern side of the lofty western part of the mountain, the extension of the ridge from this to beyond Rhotas being formed of the tertiary beds.

The section afforded by the hill is as follows in descending or natural order:—*

				Average thickness.
6.	Tertiary	Sandstone and clays chiefly, with some conglomerate beds	Sivalik ...	Only part in section, about 6,080 feet.
5.	Nummulitic limestone		... ...	Maximum 30 „
4.	Red shaly and flaggy zone, with pseudomorphic crystals ...		... ...	Very variable, about 120 „
3.	Pseudo-limestone and compact sandstone zone		... ...	150—200
2.	Black-shaly zone		... ...	200
1.	Purple sandstone zone		Saline group ...	250—300
	Purple shale and			100
	Red saline marl			20— 30

a knife-edge surmounting a precipice of several hundred feet in height, it was found necessary to proceed on all-fours. The wind came from the northward in such a way that much of the nearly two-miles-broad channel of the Boonhar river to the south just below the mountain would have been thought sheltered. So far from this being the case, it was here only that the gale seemed to take effect, raising vast clouds of sand, completely obscuring the distant country, while on either side beyond the limits of the mountain where the river course was not so sheltered the equally dry sand was not seen to rise at all. My guide observed, "*the winds are born on Tilla,*" and it certainly seemed as if its great mass had so influenced the temperature of the air that the storm was local, or its strength limited to the vicinity of the mountain: or it may have been an eddy behind the obstructing hill-mass.—A. B. W.

* For the purpose of comparison with the distant succession between the Ganges and Ravee, the following general section is abstracted from Mr. Medlicott's Memoir:—

Sub-Himalayan Series.		
Upper ...	... Sivalik ...	... Conglomerates, sandstones, and clays.
Middle...	... Nahun ...	... Lignite sandstones and clays.
Lower ...	... Subathu ...	... Kasaoli, gray and purple sandstones. Dugshai, purple sandstones and red clays. Subathu, fine silty clays, with limestone.—*(Nummulitic).*
Himalayan Series.		
Unmetamorphic—		
Krol ...	... Krol Hill ...	... Limestones.
Infra-Krol ...	ditto ...	... Carbonaceous shales or slates.
Blini ...	... Blini River ...	... Limestone and conglomerate.
Infra-Blini ..	Simla	... Slates.
Metamorphic	... ...	... Crystalline and sub-crystalline rocks.

Comparing the two sections, it will be seen that the Nahun and Subathu groups, excepting the lowest portion of the latter, are probably unrepresented on Mount Tilla; purple sandstones, if occurring at all, being quite inseparable from the remainder of the lower tertiary sandstones and clays, which, from their fossils, were identified by the late Dr. Falconer with the Sivalik rocks.

But little of the nummulitic (? Subathu) beds are seen at Tilla; and there is no appearance here of the unconformity to their underlying strata recorded by Mr. Medlicott, though this would not be reason for its non-existence. Omitting the red shaly and flaggy zone of Mount Tilla,—which is variable in thickness and not always present,—some parallel may exist between the calcareous pseudo-limestone with its underlying black shaly zone and the Krol and infra-Krol groups of Mr. Medlicott's unmetamorphic Himalayan series; but even with the aid of that gentleman's able memoir it would be hazardous at present to attempt the correlation of these rocks.

Several beds of the sections to the westward have disappeared at Tilla; notably the black-shale group beneath the nummulitic limestone, containing all the coal and coaly deposits of the eastern portion of the Salt Range, and which can hardly be said to be represented by a few traces of dark coloured shale, existing where they ought to come in.

The true red salt-marl of the Salt Range makes but a very poor show along the southern base of Mount Tilla. It can be seen in some places near the villages of Nara and Pind Sevicki, but is greatly overrun and concealed by detrital accumulations from the cliffs and hills above. Only 20 or 30 feet have been given for it in the section; the thickness would, however, doubtless much exceed this if it could be well seen. It is of the usual bright red color, and gypseous saline nature; but although salt has been manufactured from the impregnated water it discharges, no actual rock-salt has been found in it.

The upper portion of the marl is, as usual, purple, and more shaly, and is frequently seen at the base of the purple sandstone cliffs. Its thickness, as estimated, may be too great, but allowance has been made for a portion that is unseen in most of its exposures.

This shaly portion of the marl passes up rapidly into strong purple sandstones of exactly the same color. They are generally fine grained, have no pebbles scattered through them, and, from being somewhat saline, have white efflorescence, yielding easily to the weather; they contain spangles of mica; and the stronger beds, from the ease with which they can be dressed, are used as building stone. The thickness of this rock, from causes to be presently pointed out, is sometimes deceptive. It forms a very considerable portion of some of the finest cliffs, where it cannot be much less than 300 feet, though in such situations its depth could be only estimated.

Next above the purple sandstone is a strong band of dark colored gritty shales and lighter colored sandy flags and layers (2); the whole having a lumpy aspect, and glistening with mica; the deposition surfaces are frequently glossy and covered with black earthy films. In these beds *annelidan, crustacean* or *fucoid* markings are numerous; and elsewhere they have furnished the earliest traces of distinct fossils in the Salt Range, these consisting of small bivalve shells as yet undetermined; strong ripple-marks also occasionally occur. Resting immediately upon this shaly zone is a massive band of compact silicious sandstones and sub-calcareous rocks (3) of light color, often nearly white. Some of them are brecciated or pseudo-conglomeratic; and many, under the influence of the weather, assume the peculiar fantastic forms of decomposing limestone. A specimen of the latter variety from Mount Tilla yielded on analysis, according to Dr. Fleming, nearly equal parts of white quartzose sand, carbonate of lime, and carbonate of magnesia. Their rough aspect and a peculiar surface appearance, as if likely to contain fossils, has led to frequent searches, but nothing of organic form has been found beyond the obscure tracks noticed in the foregoing group. The beds are frequently massive; this character, their strength and the association with softer beds below, having doubtless been the first conditions that resulted in the fine cliffs along the southern face of the range. Many valuable building stones could be obtained from this group, and some are said by Dr. Fleming to bear a high polish (Jour., Asiat. Soc., Beng., Vol. xxii, p. 265).

The next overlying group (4) is largely developed only at the western end of the range. It presents a strong contrast to that just mentioned, being formed of deep-red flags and shales, sometimes spotted with green, the flaggy slabs being often studded with projecting angles of casts of cubic crystals, the mineral—in all probability salt—having been entirely replaced by sand. The flaggy layers are frequently of light color internally, the bright-red hue being derived from the intervening earthy shale layers highly charged with iron-oxides. The latter become more numerous upwards, until the superior portion of the band is found to consist entirely of crimson and purple clay or shale. This group occupies a good deal of the ground from near Pind Sevicki by Choya Goojaron-ki, and above Nara; beyond which place it passes to the north side of the mountain, becomes thin, and thereafter is seen but fugitively here and there as well as near the summit.*

In some spots, particularly on the northern slopes of the mountain, vestiges of the nummulitic limestone group (5) so largely developed westward are apparent, resting either upon the red zone or, in its absence, upon the strong band beneath. It is seldom at all clearly seen; generally appearing as a thin white streak of debris, somewhat shifted and borne down the hill, and often overrun by other detritus; but at one spot, where rather thicker than usual, it was found to consist mainly of the white, lumpy or yellowish variety usually occurring near the base of the group. Some gray, compact beds overlie this; and there are traces of a few dark shales in its lower part, as also of a peculiar bed of compact, variegated, red and white clay rock, frequently observed elsewhere at the base of this limestone group. The rocks on Mount Tilla contain but few of the numerous fossils of the group so far as could be seen.

A small outlier of this limestone occurs below the road north-east of the houses on the summit of the hill, having subsided with the other strata along a fault; and in the opposite direction, just beneath the precipice on the edge of which the highest bungalow is perched, remnants of the variegated clay-bed before mentioned indicate that the limestone has barely been removed if, indeed, some of it *in situ* is not concealed by sub-aerial rain-wash.

The inferior portion of the Sivalik group (6), which rests apparently with complete conformity upon the nummulitic limestone, is mainly composed of strong, gray sandstones of rough texture and softer nature than any of those lower in the series. Thick beds of lumpy pseudo-conglomeratic shale also occur, and some beds of red, shaly or marly clay. Large fragments of silicified fossil wood are very numerous in some localities, particularly on top of the western end of the mountain. Over these clays comes a broad zone in which the sandstones alternate with thick beds of red clay at the northern base of the hill for fully 1,600 feet; and this zone is succeeded by another of probably much greater thickness, in which the intercalated beds of clay are of a pale brown color, there being little difference in the sandstones throughout.

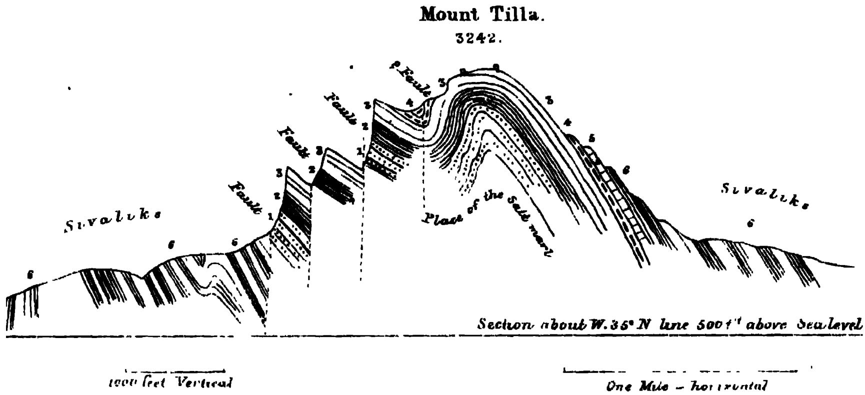
The less elevated continuation of the ridge from Mount Tilla proper on by Rhotas is formed almost entirely of what appear to be the lower portion of these Sivalik rocks, greatly crushed and contorted, generally inclined at steep angles to the north-west, but in some places more nearly horizontal; while contrary dips occur on the Jhelum (or south-east) side of this extension of the ridge.

To the eastward and east by north of Rhotas, the termination of the Tilla chain is fringed by low, rounded hills of loose conglomerate or pebble beds, mainly composed of smooth well-worn limestone and metamorphic rock debris. These pebble beds also appear, generally in a disintegrated state, in the fine anticlinal section of the Kahan gorge near Rhotas, and in one place were seen to rest unconformably upon the Sivalik rocks; but, owing to the extremely incoherent nature of the rock and its liability to have its debris re-arranged by atmospheric action, this cannot be asserted without considerable doubt; though to the east, along and near the Grand Trunk Road, the general arrangement of the conglomerate seemed discordant to the undulating dips of the Sivalik beds; while the way in which the hills were overrun with pebbles and boulders left small hope of satisfactory evidence being here obtained upon the point.

Besides the fossil wood observed upon Mount Tilla, some fine mammalian remains were formerly procured from the Sivalik beds between that and Rhotas, and were determined by Dr. Falconer, as already mentioned. A set of beds containing numerous imperfect fragments of these bones runs along the summit of this lower portion of the ridge close by the road from Rhotas to Tilla, near a place called Thurbole. The bones were found in a fragmentary state, imbedded in the matrix as well as lying loose upon the surface, but though some time was spent in the search, few useful specimens unfortunately could be obtained; and, to procure such, a subsequent and special mission would be probably required.

* The thinning out of this red zone may, perhaps, be partly due to pressure and slipping on the highly inclined slope of the beds at the north side of the hill, where the flaggy lower portion only is seen.

It will perhaps be observed that—though, as has been said, the lofty portion of the ridge of Mount Tilla coincides with a fractured anticlinal curvature of the strata which might be expected to assume approximate horizontality on the axis of the ridge—the height of the hill is given at over 3,200 feet, while the total amount of the thicknesses of groups in the sectional table only reaches about 1,000 feet, excluding the tertiary Sivalik rocks which mainly lie in the plain below and on the northern slopes of the hill. To explain this seeming discrepancy, it may be stated, *1st*, that the height of 3,200 feet is attained by the mountain just at the point where the beds commence to turn over: *2nd*, that the axis of the contortion rises towards the summit of the hill: *3rd*, that 800 or perhaps 900 feet must be allowed for the height of the general southern base (the outcrop side) of the mountain, and that a considerable sloping talus above this is formed of slipped masses and debris at the top of which the section of the vertical cliffs begins to become visible. Added to these there are three, if not four, step-faults along the south-eastern side of the highest part of the hill, each of which repeats some portion of the strata, as seen in the accompanying sketch section :—



Section across Mount Tilla, looking south-west.

1. Purple sandstone.
2. Black, shaly zone.
3. Pseudo-limestone and compact sandstone.
4. Red, shaly, and flaggy zone.
5. Nummulitic limestone.
6. Tertiary (Sivalik) beds.

With regard to the physical structure of the remainder of the hill, the upper portion of the anticlinal curve expands to the west, beyond two deep coombs or glens, one of which opens broadly to the south, but enters into the very heart of the mountain; this expansion of the arch being accompanied by so slight a southerly dip that the lower members of the series present, even to the lowest of all (the red marl), appear at the base of the hill along a line which sinks gently to the west-south-west.

Along the Boonhar fault in this neighbourhood, some difference in the section is perceptible, the group No. 2 of the above figure having apparently thinned out both on the Tilla and the opposite side of the gorge: the purple band beneath seems to be also thinner; but the ground is much obscured by local slips, small faults, and large detritus from the pseudo-limestone group which, with many undulations, sheets the hilly ground or plateau about Choya.

Beyond this plateau and above it a somewhat tortuous cliff-line extends along the brow of the hill, broadly edged by the nearly horizontally rolling beds of the red, flaggy, and shaly band; while the tertiary strata of the plain beneath rise at a steep angle on the northern slopes, and, like the crest of a wave, overlap the ridge, forming most of the lofty ground westward of the summit.

The extreme western termination of the hill is very abrupt, and some complicated faulting occurs just at Pind Sevicki, the last of the high ground being formed of the red, flaggy, and the underlying group, either vertical along a west-north-west line (coinciding with that of the Chambal scarp), or dipping with the steep ground at high angles to the westward, but curving suddenly round the peak called Thob, at which place the north-westerly inclinations commence, that fix the steep character of all the northern side of the lofty ground. Round this peak of Thob, too, as a centre the strongly marked strata of the Sivalik (tertiary) group are boldly curved so as to enfold those which form the hill; the former, all more or less on edge, being frequently so perfectly vertical that all trace of their outward dip is lost.

At the north-eastern extremity of the lofty ground the dislocation of the rocks is accompanied by violent contortion both of the Sivalik and older beds, its intensity diminishing considerably along the lower extension of the ridge to the north-east.

Gold is said to be washed from the sand of the Boonhar river. Its source is probably among the Sivalik sandstones and conglomerates, formed of Himalayan detritus. The washing is carried on after rain.

The summit of Mount Tilla, though affording small space of at all level ground, will doubtless attract attention as a sanitarium within easy reach of the Military station of Jhelum. It commands a splendid view of the snowy Pir Punjal range; is said to be, and most probably is, much cooler than the plains, for when visited on an extremely hot April day, the temperature in the shade was very refreshing.

A road in excellent repair, save where it passes through the tertiary ravine-ground near Dariala, leads from Jhelum to the houses on the summit; and the hill, though by no means completely bare on top or on the northern slopes, is not crowded with jungle.

The chief difficulty, as usual, would be a large and continuous supply of water. Extensive tanks exist, one of which is well placed, but lies rather low in order to obtain a catchment basin. The disposition of the strata affords little encouragement to sink wells; though the black, shaly zone might be found retentive. Some springs there are, and others might be found, where the tertiary strata cap the ridge, but this is at a distance of from four to six miles, and a road would have to be made to them, so that probably the best method of increasing the supply would be by multiplying the number of tanks and making them as little liable to leakage as possible, one large structure of the kind on the north side of the hill having been found quite empty, owing, as was said, to this fact of its leaking.

The Copper Deposits of Dhalbhúm and Singhbhúm.

The following papers on these copper deposits consist of, *1st*, abstracts of two papers by M. Emil Stœhr, the accomplished mining geologist employed by the Company formed to work the mines; one in the "Vierteljahrschrift der Naturforschenden Gesellschaft" in Zurich, Vol. V, p. 329, 1860; the other in the "Neues Jahrbuch fur Min. Geo. u. Pal." for 1864; and, *2ndly*, a recent report by Mr. V. Ball, of the Geological Survey. Scientific observations in connection with mining operations in India are so rare that it is important to place the experience and the opinions of M. Stœhr on record in a form easily accessible to the Indian public. The works being abandoned, the mine-sections were not accessible to the Geological Surveyors. The localities mentioned by M. Stœhr may be followed upon the map attached to the second paper.

1.—The Copper Mines of Singhbhúm, by M. Emil Stœhr.

1. *General Geological features: Schists.*—It is only in the south and west of the region under notice that granite and gneiss-granite appear, forming dome-shaped hillocks seldom more than 100 feet above the flat. The old rock-formations—metamorphics—of Lyell behave very differently; they form a system of parallel ridges from west-north-west to east-south-east, ranging in elevation to 1,900 feet and under. The strike of the ridges is for the most part the same as that of the schists, except in a few places to the east; up to Sideshor the strike varies from east-7°-south to east-30°-south; from there it is east 37°-to 60°-south. The dip is constantly to northwards, at from 15° to 50,° mostly from 20° to 35°. This structure decides the form of the hills—steep on the south and sloping on the north.

These schists present many varieties, scarcely any form of metamorphic rock is unrepresented; clay-slate of the most various types, from soft clay-slate to roofing slate, with quartzose varieties, or sometimes quartzites; forming the ridges; mica-, chlorite-, talc-, hornblende-, and quartz-schist with quartz-rock are the most prevalent. Occasionally gneiss is found, but without any continuity or constant position in the series. There is a peculiar rock composed of round grains of quartz in great number (often exceeding the matrix) in a base of clay-slate. At the junction of the sedimentaries and the granitics there occurs a strange quartzose formation, a true arkose, many feet thick and almost vertical; in which are found angular fragments of the different metamorphics, in a fine quartzose mass. Of minerals I obtained garnet, schorl, kyanite, rhatizite, and chloritoid (of Kenngott); also a blue-black mineral of an elongated form, which Kenngott considered to be apatite united with a carbonaceous substance.

2. *Greenstone dykes.*—The irregularities that these ranges exhibit are due to the presence of transverse dykes, especially of diorite. Simple inspection cannot determine whether the greenstone is amphibolic or pyroxenic—diorite or diobase; I incline to consider it diorite. Generally hard, it often becomes soft, changing to aphanite; at Paraum near Dhoba it is almost serpentinous, containing nearly 10 per cent. of water. Not far off are considerable runs of potstone, which this aphanite seems at all events to approach. In other places the greenstone passes into greenstone-schist, following the strike of the series. Although these dykes do not always come to the surface, they can be traced at intervals in long ridges recognisable from a distance as longitudinally extended lines of conical hills, generally double-topped. The strike of these diorite masses varies, generally north and south, or 15° on either side. Where such a north-south range crosses those of the older rocks all is confused; still a most picturesque conical hill always detaches itself from the mass. This very hornblendic diorite has a remarkable tendency to spheroidal structure, and appears on the summits split into vertical columns, like ruined castles. It is noteworthy that one often finds such clefts with quite fresh surfaces of fracture: this is the result of the sudden cooling by rain of the rocks when highly heated by the sun's rays, as I determined by direct experiment. These diorites are so rich in iron that they often disturb the magnetic needle, and weather into iron-sand. The diorite cones seldom form considerable elevations; but this is not without exception, as at Bagmuri, 2,000 feet high. Where the diorites come in contact with the sedimentaries these are altogether metamorphosed; basalt-jasper occurs; the schists are calcined, and columnar divisions are frequent. These greenstones are not limited to the north and south dykes.

Whether the introduction of the greenstones has had any connection with the appearance of the copper ore must for the present remain undetermined; it would seem the more likely, inasmuch as the potstone and serpentine formation is certainly so connected.

3. *Granitics.*—These diorites run into the granitic area to the south and west; where gneiss-granite and, less frequently, true granite form dome-shaped hills; these also here observe an east-west direction in long parallel ranges above the plain, traversed by the north-south diorites—an arrangement that gives to the whole area a strange chessboard-like aspect. At the intersections of the two systems of ranges, the most picturesque cones occur; and remarkable development of mica appears in the granitic rock, so that the mica is applied to many ornamental purposes.

4. *Laterite.*—In India many different formations are grouped under the name of laterite. There is the laterite of the plains formed of detrital matter into which the iron constituent came from without, probably from springs; such is the laterite of Midnapur. From these are to be distinguished that which owes its formation to the decomposition *in situ* of ferriferous rocks; such is the only laterite known to me in our district, as on the summit of Mahadeo, derived from the ferriferous diorites.

5. *Mineral products.*—I have already mentioned the potstone that is worked into various utensils. I may here notice an ochreous schist that is used as a dye. Of ores there are—iron ore, sometimes as a vein, sometimes stratified; mostly pure magnetic iron (see Berg- und Huttenmännischen Zeitung for 1863); seldom red hæmatite, and once only brown hæmatite; then the rich copper ore, which was the object of my journey to India.

6. *Copper ore: its range.*—This copper ore would be interesting if only on account of its unusual longitudinal extension—for 80 miles if not more. I have examined it more closely through a length of 65 miles, from Lopso hill in the west to as far as Badia in the east. I know nothing of its further distribution in the western forest-clad hills, but in its eastern range it goes far beyond Badia to Bairagurha, the most south-east point on my map; and so far as I examined the intermediate hills, traces of the ore were found everywhere; but in its longitudinal range, it appears most in the northern hills.

7. *A lode, or bedded.*—The strike and dip so coincide with those of the containing strata that one is induced to consider the mineral deposit as stratified; against such a supposition there is the vein-like mode of deposit, the frequent cuirasses and slickensides, the occurrence of druses, and the broken outcrop. At all events the deposit is a filling of

cracks parallel to the layers of the containing rock; and the formation of these cracks was probably contemporaneous with the upraising of the schists. Following the structure of the containing rock, the deposit was originally variously irregular; and this condition was aggravated by the intrusion of the diorite.

8. *Several outcrops.*—Proceeding from north to south there frequently appear two or even three consecutive runs of copper ore; it would thus seem, partly that one and the same band was brought several times to the surface by upheavals, partly that a system of parallel deposits truly exists. At all events we can recognise at several places two parallel ridges, or lines of outcrop, sometimes miles apart, sometimes coming so close that they almost commingle. Going from west to east we find, quite to the west, near the Lopso hills, two runs of ore scarcely ten minutes from each other; a third more northern locality seems only due to a local disturbance. These two runs separate to eastward, being several miles apart at Khursowa, until they appear to come together again in the Akarsuni hill. From there to Tamba-dungri (copper hill) the deposit is buried beneath the deep soil of the plains. At Tamba-dungri one run appears which can be traced over Jamjura, then bending southward to Landu, and then again northwards to the summit of the conical hill Chundra. A little north from Jamjura a second band shows, which runs northwards from Landu to Chundra, at the summit of which these two runs are scarcely two fathoms apart. From here the two separate again, one goes south to Matku in the plain, where it is concealed; one to Hitku, Banka, etc., in the north flanks of the Rangi hills. Here there is a break of several miles where I was not fortunate enough to find the ore: finally it appears again at Racka and proceeds then in a long line following the north hill-flank. Between Bindrabun and Sideshor the strike alters, from east-37°-south to east-60°-south; also the intruding diorites disturb the rocks much, and with them the deposit. In their further course eastward the hills trend rather back, and the deposit gets gradually into the plains. At Pathur-ghora, we find again two lodes, probably, however, only the broken parts of one and the same main lode which unite at Bairagurha. From here all goes straight, except once at Karapathur there is a disturbance; the contorted and crushed strata are confused and the rock almost altered into gneiss. These schists are stuck up to north by a south to north upheaval, and twisted round the Karapathur, till at last all becomes normal again.

9. *Varieties of the ore and gangue.*—As for the ores themselves:—when removed from the influence of the atmosphere the iron ores are, mostly magnetic iron, less often pyrites: the copper ore, too, is seldom pyrites, mostly glance-copper and red copper ore; either ore indeed is seldom pure, but mostly the two in intimate variable mixture, so they almost form a peculiar ore of blue-red colour, soft, and with red streak. According to several analyses (among others by Fresenius and Roth of Heidelberg) the proportion of sulphur varies from 9 and more per cent. to complete absence; and also the total of copper from 42 to 64 per cent.; the ore is always contaminated with iron, from 5 to 12 per cent. It seems that when sulphur is quite absent, glance-copper is also wanting and the red-copper is not pure but mixed with black-copper; also in many places black copper occurs in strings and disseminated, and is used by the native beauties as a black dye for the teeth. Beautiful rosettes of red-copper appear detached, no doubt the result of decomposition. In the upper levels the saline ores occur as the result of alteration, malachite, less often azurite, and brown spar. The whole gangue and ore are often so decomposed that these products are formed to a depth of 15 fathoms. As a ternary product of decomposition, on the heaps and scattered, I may mention chrysocolla, libethenite, and chalcophyllite.

I must again notice the intense atmospheric action; often at the depth of 30 running fathoms the decomposition had not ended; the earthy quartzite-schist had become decomposed and penetrated with malachite and brown iron ore.

Malachite, in solid masses, compact and earthy, seldom fibrous; in the upper levels the only ore, where it occurs in film and fragments, or mixed with brown hæmatite, impregnating the whole gangue, which then contains from 2 to 8 per cent. of copper. It occurs besides as infiltrations in cracks and slender clefts where a rich deposit ends or begins. It is always more or less mixed with silicious earth and ochre; the purest pieces give—

Oxide of copper	54·73
Iron oxide	6·20
Water	6·87
Carbonic acid	15·15
Alumina	·83
Insoluble	15·95
	99·73

Red copper ore, in solid masses from the size of a nut to several feet in diameter in a silicious matrix, sometimes filling the whole lode and enclosing angular pieces of quartz, sometimes in strings and flakes ramifying through the rock. This is the most important ore, seldom indeed pure, almost always mixed with black copper and iron oxide. As the malachite is due to the further decomposition of this ore, so is it of glance-copper; some specimens show the three states. It is difficult to find red copper entirely free from copper-glance; apparently pure red copper specimens have given 8 per cent. of sulphur. The mixture with iron oxide varies from 0·25 to 18 per cent. It is too always mixed with black copper; and it was interesting to know if the proportion were constant; analysis showed it to vary from 63·7 per cent. sub-oxide and 33·6 of oxide to 50·14 per cent. of sub-oxide and 46·74 of the oxide. It is only an indefinite mixture. Often the oxyde is in excess, the ore being dark brown, with black metallic streak. The common variety is brown red to cochineal red, with red streak, and in pure pieces, a fine crystalline texture. This quality, with hardness of 3, sp. gr. 5·623, gave—

Sub-oxide	63·72
Black oxide	33·60
Silica	1·02
Alumina and iron	0·75
Lime	0·64
Magnesia	0·10
	99·83

Others gave traces of manganese and bismuth.

Black copper occurs only as a coating, and at most in strings as thick as the back of a knife and always mixed with red copper and iron oxide.

Copper-glance, massive, mostly in kernels. It is at all events the original undecomposed ore; seldom pure, almost always with iron oxide.

Copper pyrites seldom found; and only sprinkled here and there.

Azurite, as a crust. It is remarkable how seldom it appears where malachite is so abundant; I only know of one locality.

Libethenite and *Chalcophyllite*, in small crystals in the old refuse heaps; similarly *Chrysocolla*.

Native copper, in massy rosettes and flakes; rare, and only where surface water can penetrate; associated with malachite, of which it seems to be a reduction and not of red copper.

Copper uranite was found on Lopso.

Iron ores.—Brown iron ore; in the upper levels often filling the whole lode, as ochre or as solid brown hæmatite.

Magnetic iron in crystalline granular masses, sometimes even filling the whole lode mostly mixed with specular iron (Eisenglanz). Analyses of fragments of the old copper regulus gave traces of silver and gold, and 10 per cent. of iron. Assays made in London proved the ores to contain silver: an ore of 31 per cent. of copper gave 0·0078 per cent. of silver, one of 60 per cent. of copper gave 0·0039 of silver. The silver then cannot be principally contained in the copper ore, but in the gangue.

10. *Distribution of the ore.*—Copper is not the only metal this deposit contains; iron predominates; so that one may describe the deposit as one of iron ore rich in copper. The copper-contents are themselves very variable, from traces up to the richest ore. The action of the intruded diorites appears to influence the proportion of copper; they may come quite to the surface or only produce a north-south upheaval, the richest copper deposits always being in their neighbourhood. In the preponderating quartzose gangue the ores occur in leaves or threads, from paper thickness to several inches, ramifying through the mass; sometimes binding angular quartz fragments, sometimes in compact masses; often filling the whole vein. Elsewhere they show in lenticular lumps from the size of a hazelnut to that of the head, having then generally a covering of talc or chlorite in the quartzose base. Sometimes, but seldom, the quartzose veinstone fails, and contorted, crushed, broken chlorite- and talc-schist enclose lumps of quartz and strings and pieces of ore. Once or twice the veinstone was quite porphyritic.

The roof and floor of the deposit are not confined to any particular kind of rock of the metamorphic series; many different rocks occur as such,—clay-slate, chlorite-, talc- and mica-schist; but always a schist; quartz rock never occurs as roof and floor. The strike is the same as that of the rocks; in the west, from east-west to east-35°-south; in the east so much as east-60°-south. The dip is 15° to 50° to northward, mostly 20° to 36°. The normal width of the lode is 20 to 22 inches, at which the ore is richest; sometimes filling the whole vein. It often expands to three feet and over; but then the ore scatters and the richness suffers. Whether a workable ore extends, and how deep, is unknown; the ancients only worked that nearest the surface; but wherever I opened old works and went deeper good ore was found, generally after cutting through some poor ground, so that at 100 to 120 feet the ore still always held out. At the time of my departure the point at which research had been carried farthest was at Landu; there 212 feet had been reached, but already at 190 feet the ore had decreased, and at last was quite lost. Whether there only happened to be poor ground at this spot, or whether generally the ore does not extend to the deep, is unascertained: I would almost decide for the latter opinion. The deposit is of course not worth working throughout its entire extent; but rich parts alternate with poor or even with barren; to find the first was therefore the chief endeavour; and we were successful at many points in finding such rich localities.

In the Lopso and Sirsu section the ore is associated with quartz- and mica-schist.

At Podumpur with a sandy mica-schist containing schorl.

At Akarsuni with black mica-schist and quartzose clay-slate, close to greenstone; granite also shows in the neighbourhood. The detritus on this granite is washed for gold.

At Tamba-dungri, a greenstone that does not reach the surface seems to have raised the schists and partly metamorphosed them locally into gneiss and quasi-granite, and the ferruginous schist into jasper. The top of the hill is burrowed all over with little pits 60 feet deep.

The northern run at Landu is in quartzose schist accompanied by mica-and chlorite-schist: the southern in mica- and chlorite-schist with associated quartz.

At Chundra the ore occurs with quartz gangue in mica- and chlorite-schist and quartzose clay-slate.

At Matku in the quartzose clay-slate and quartz-schist.

The northern lode at Chura-dungri and Hitku is in quartz-schist; at Pahlu-dungri in chlorite-schist; at Banka it is greatly disturbed and seems to be cut out suddenly by a mass of potstone.

At Racka and Bagh-ghura the rock is sandy schist and quartzite, but mica-, chlorite- and talc-schist are not absent. It was here that disthene-rock was found. The ore is in a silicious schist and occasionally in mica- (black mica), actinolite- and chlorite-schist.

At Sukurna, near Sideshor, the ore is in silicious schist, associated with mica-, chlorite- and quartz-schist. Sideshor appears to be the production of a penetrating north-south upheaval; and in its quartzites traces of the ore are found, as malachite,—a proof that many beds of the metamorphic series are cupriferous. At Bindrabun immediately under the ore is a massive rock composed of quartz and tourmaline with a little mica,—a granite formation, except that felspar is wanting; one might almost call it greisen. A run of jasper occurs close by, in the formation of which, as well as in the elevating of Sideshor, this peculiar rock may have taken part. Malachite traces are found in it too.

At Pathur dungri the rock is quartz-schist; but on the south-west of the hill ore occurs in mica-, chlorite-and hornblende-schist.

At Súrda the ore is in dark mica-schist containing garnet, chlorotoid, and hornblende crystals. Near Pathurghora the ore is in more or less metamorphic schist; near the village red felspar is associated, and the rock becomes granitoid.

The distribution of the ore in the lode follows no certain order; unless one is to consider as such its constant association with quartz, which is always the preponderating gangue. From the agreement of the dip and strike of the deposit with that of rocks, one would consider it as a stratified ore, were there not much against such a supposition. I do not here allude to the cuirasses and quartz druses, but especially to the variable strength of the deposit itself, and the interruption and separations of the outcrops; which then again follow the strata and lie in many patches close to each other. The normal thickness may be about 20 inches; in rich spots it reaches 3 feet; while elsewhere it intermits, the deposit is compressed and decreased with only scattered ore, till this also disappears and the deposit can no longer be traced. All this suggests to me separate lodes, *i. e.*, an impregnation of cracks parallel to the rocks, and probably formed at the time of their elevation.

11. *Peculiar carbonaceous mineral.*—I conclude this short description of the deposit with a notice of a mineralogical peculiarity occurring in it. At Jamjura the lode was sought for beneath the thick soil of the plains, and found with good ore. In this newly opened work a fault was struck, in the neighbourhood of which the veinstone seemed quite altered, the quartzose mass had become almost porous, the quartz had lost its lustre, and had become almost friable. In this rock and in the ore itself there occurred as rarities in, as it seemed, octahedral or rhombohedral cavities, loose pieces of a peculiar coal-like substance. It was found at 37 feet below the surface, or at 100 feet along the slope of the deposit, at 30°. I had early sent from India some specimens to Bergrath Breithaupt at Freiberg, who has described this strange mineral in the Mining and Metallurgical Journal for 3rd January 1859, from which I here give an abstract of the principal characters:—black; semi-metallic lustre on fresh fracture; black streak; opaque; blunt pieces of size of an egg and under; internally crystalline, very fine grained; sp., gr. 1·92; hardness 4·25 to 4·75, between calc and fluor spar; brittle; very difficult to burn before the blowpipe. Composition, mean of Sheerer and Ruhe:—

Carbon	93·945
Water	1·440
Acid	2·895
Ash	1·720
	100·

It is considered by Breithaupt as a middle condition between anthracite and graphite.

Breithaupt thinks that the tabular impressions on the carbon may be due to calcspar—that in the druses calcspar crystals were produced. This is surely an error, for I never saw such crystals; on the contrary, the coaly matter is loose in cavities lined with lamellar quartz, which is often imposed upon it. The hardness given by Breithaupt is not correct for all the specimens; many are easily scratched by calcspar. I would mention that I possessed a piece of veinstone which together with this mineral contained undoubted flakes of graphite, as also two different forms of the mineral close together.

Professor Kenngott and Escher de la Linth have more closely examined this substance; on the same veinstone were found white particles of a silicious substance with a deep black nucleus, the white exterior being the result of decomposition; hence Professor Kenngott takes this substance to be the remains of the decomposition of a highly carbonaceous silicious mineral, whereby the silica was removed, leaving the carbon.

12. *Mining experiments.*—In order to exhibit the special conditions of the deposit I will now describe the most important mining experiments. Special mining experiments could not be attempted over the whole area within little more than three years' time; they were limited to between Jamjura and Rangi. Landu was the centre; there were extensive old works there, and the flat ground offered an untouched field for exploration. The diggings that gave the best opening were No. 1, near Landu, in the north lode. At 7½ running fathoms we got to the end of the old workings, where the width, originally considerable, was reduced to 15 inches. There was great trouble in getting the men to continue the work; and when, among a lot of jackal bones, a piece of a human skull was found, all green with copper, great terror spread, and only the most pressing representations, that the skull must have been brought there by some beast of prey and did not belong to a man who had perished on the spot, could induce the men to carry on the work. The layer was only 15 inches from roof to floor, almost filled with rotten slate and quartz fragments, rich in iron, but almost without copper, only here and there a sprinkle of malachite incrustation. The ancients had evidently abstracted all the good ore till they came to this barren run. After a little the malachite increased, enveloping the quartz, and so ramifying through the still broken schist that it yielded from 1·8 to 4·5 per cent. of copper. The roof and floor were of chlorite-schist, quite devoid of copper save by infiltration in the little cracks. At 12·7 running fathoms strings of malachite occurred one-half of an inch thick; and the lode was 2 feet wide. From here it increased; and at 15½ fathoms an easterly drift was started that soon disclosed the most splendid ore; first malachite, then this passing into red-copper, and this again into glance-copper. This ore finally filled the

whole vein, 3 feet thick, enclosing angular pieces of quartz; and also occurred in large elliptical nodules several feet in diameter lying in a gangue of silicious slate, in such numbers that a fine roof-face could be worked; at 25 fathoms along the drift, the lode split, one branch going southwards soon became barren, while the northern one yielded fine ore. In a northern trial-drift from here another vein was cut more or less rich in ore, and still further eastward three others. Down from this drift a small hading shaft was sunk; and here, at 28½ fathoms the ore began to decrease, and died out altogether. So far the underlie was 35°; here it rose to 60° or 70°; the thickness of the lode decreasing to a few inches; below this trouble it became flatter again and traces of ore re-appeared, till at 32 fathoms this too disappeared with a new trouble. It was in this state of affairs that the hand pumps could no longer keep under the water of the rainy season, and the progress discontinued at 12 fathoms vertical from the level of the valley.

Four miles to the west, at Jamjura, under the alluvium of the plain, a very rich ore was cut, occurring in a very similar manner to that at Landu. At 18 fathoms the ore was still good. In a westerly direction it was less rich, but continued to eastward. In a trouble of this vein the carbonaceous mineral was found; not only in quartz, but in solid malachite. Here, too, was found the *native* copper, reduced from malachite by the action of this carbon.

A third important locality was No. 6 of Landu, in the south lode; chlorite-schist and sandy mica-schist contain grains and nodules of quartz, often coated with talc; these are sometimes several feet in diameter. In and around these generally flattened lumps, partly following the layers of the schist, partly, too, itself forming kernels, or surrounding fragments of quartz, comes the ore in threads, from the thickness of a knife to several inches, thus uninterruptedly arranged in nuts and lumps, and in this manner forming the lode, 18 to 24 inches wide. These conditions obtained to 16 running fathoms, then the ore ceased, and at my departure the work was in barren rock. In the upper part the ore was all malachite, but in the hard undecomposed masses there was a mixture of red and black copper with glance-copper. The ore was besides always very rich in iron. At about 80 fathoms to the east, in a small trial pit, the lode was almost entirely made up of coarsely granular crystalline magnetic iron.

At Hitku in the northern, and Matku in the southern, lode there occurred quartzose, porphyry-like gangue; and the ore predominated as nodules of oxides, with glance-copper. In neither place was it worth working, appearing to cease in depth.

At Banka a clear-ringing, columnar, fissured quartzite is penetrated in every direction by thin strings of ore, black, with glance-copper. Sometimes it is scattered through the quartzite, giving it a porphyritic aspect; the quartz being then altered, dull, fragile as if burnt. Low down there appeared an agglomeration of quartzose talc-schist and nearly massive talc, where the lode stopped out suddenly.

According to the results at Landu, the cubic fathom of 96 to 150 cwts. of raw ore gave an average of 6 per cent. of copper; and the cost of extraction of the same, including haulage, amounted to Rs. 22 to 23 per 100 cwts. of raw ore.

The preparation by hand-picking must be regulated according to the proportion of saline ores; here the average of 100 cwts. of raw ore was—

3 cwts. of rich picked ore of	... ...	20 to 35 per cent. copper.	
60 " average ore of	... ...	8 " 9 " "	
13 " dust ore of	... ...	0 " 5 " "	
24 " rubble and poor ore of	... ...	¾ " 1½ " "	

All the poor ore was considered as rubble for crushing. In the best rubble there occurred but 8 to 10 per cent., very seldom 20 per cent.

13. *Labour.*—Most of the coolies were Dhangha Kols. On the whole, they proved themselves very intelligent and skillful; on an average more so than our European workmen; only they are weaker; but, whether mentally or bodily, they are very slothful, so that they require constant watching. The daily wage of a workman is 4 to 6 pice; with which they receive the powder and tools supplied; yet job-work was only undertaken by experienced workmen. The gang at one face could not amount to less than four to six men. It was impossible to get the people to work uninterruptedly, so that a face 1½ fathoms high thus worked only advanced 0-8 of a fathom monthly.

14. *Prospects.*—Since 1862 great endeavours have been made in London to get up a limited company with £120,000 capital to work the Singhbhúm mines. The original company

had dissolved about 1859; its history was this: after Captain Haughton in 1854, in the Journal, As. Society, Bengal, had first called attention to the mineral treasures of the district, two Calcutta merchants resolved to start mines, and I went to Bengal by their instructions to make investigations and to establish the mining. When it was certified that at many places fine ore occurred a company was formed in 1857, having at its head the two original firms; and everything was then started on a very great scale. Mining commenced at Landu and Jamjura, and fine raw ore was turned out at the rate of 1,200 to 1,300 cwts. monthly. Other works were at that time not yet opened and in order; still already the erection of a foundry with steam engine at a great cost was insisted on: and consequently, after my departure, what was expected befell: there was not yet enough ore there for the supply of a large foundry; the company dissolved in 1859; and the stores, building, and machinery fell to a transferee at an insignificant price. So very costly a management had only accelerated the dissolution of the company. In India every administration is costly: here it was the case in a remarkable degree, as this single circumstance fully proves—Rs. 9,200 had to be paid yearly to the two rajahs of Ghatsilla and Seraikela, in whose land the works were situated, for the right of mining and smelting.

As above stated, since 1862 great exertion has been made to form a grand new company; and in the prospectus mention is made of my name with reference to my report to the former company, so I do not hesitate to declare that without further information than that already known and established—so long as nothing positive is settled regarding the continuation of the ore in depth—the formation of a company with a capital of £1,20,000 is unwarrantable. Ore, and very fine ore, is undoubtedly to be got; and the works already undertaken might be carried on to advantage in spite of the deficient communications, if with moderate expectations an economical enterprise be undertaken, but for this so colossal a company is not suited. If the works are to be again established, mining experiments should be extended before everything, and according to the results thus obtained such a company might be formed or not. No one could expect an exhaustive judgment from the works already accomplished, and considering the time spent upon them, the first surface labor took place in the end of 1855, and already in 1859 all was discontinued.

15. *Ancient mines.*—Almost wherever the deposit comes to-day and is not concealed beneath the alluvium one finds old buildings and refuse heaps, where there was formerly a mine. In spite of the rudeness of the mode of extraction the work must be admitted to have been sagaciously conducted. The ancients never went deep; sometimes hindered by the water which everywhere is reached below the level of the valleys, sometimes by the fear of working under ground. The use of powder in blasting must have been unknown to the people of that time, for I everywhere found in the old works, where open, single pillars undisturbed, very rich in ore, but in such hard rock as only to be won by blasting. The ancients seem to have smelted the ore in little furnaces on the spot, for one finds remains of walls, heaps of slag, and even copper bloom in many places. It is impossible to determine the age of the old workings; the heaps and fallen-in pits are mostly overgrown by thick jungle and covered by old trees; only here and there one finds large openings in the rock, at present the refuge of crowds of bats, whose dung covers the floor more than a foot deep; the cavity itself being converted into a beautiful green hall by a thick crust of malachite. If one asks the inhabitants when such work was in progress, they do not know; and they speak of 100 years with the vague ideas of Asiatics about time, representing thereby an arbitrarily long period. It seems to me, however, certain that the present half-wild inhabitants are not in a condition to carry out such works; and these may be the relics of an ancient civilization, like the rock-temples of the neighbouring Orissa, like the fruit trees (mango and tamarind) that one often finds as very old trees in the middle of the thickest forest; as again the remains of the great town Dulmi, which once stood in the thick woods of the Subanrika. Only one story has reached me of the ancient mines. Where from the lofty Sideshor, the ridges of Bindrabun, Ruamgurh, and Mahadeo descend into the valleys as spurs, one finds on Bindrabun extensive old diggings and pits, and on Ruamgurh slag-heaps and remains of brick walls. There, at Ruamgurh, a rajah of the name of Ruam must have lived and have made the diggings and houses. In the story this rajah is reported to have had two tongues,* so I must consider him as a person who spoke two languages, in fact a foreigner. The period may have been the 11th century, when the Kingdom of Orissa flourished.

* For another explanation of the two tongues, see a paper by Mr. Ball, Proc. As. Soc., Bengal, June 1869.

2.—ON THE COPPER OF DHALBHÚM AND SINGHBHÚM, by V. BALL, B. A., Geological Survey of India.

The district of Singhbhúm, first brought to the notice of the British in the year 1820, when the internal disturbances rendered interference necessary, was not placed permanently under British officers until 1836. In the interval that elapsed between these two periods, the discovery of copper and ancient native copper mines appears to have been made.

The first published intimation of the existence of copper in Dhalbhúm was given in 1833 in a paper by a Mr. Jones* who was engaged in making researches regarding the coal of Bengal. He writes—"I have reason to suppose copper may be found in Dhalbhúm near Ragwaha (Rajdoha) in a stream called Gura Nadi that empties itself into the Subanrika." Whether this supposition, which subsequent investigation has proved to have been well founded, was based on information received from natives or from personal observation we are not informed.

In the year 1854, the existence of extensive copper deposits which had been much worked by the ancients in the above-named districts was forcibly impressed upon public notice by Captain now Colonel J. C. Haughton, Assistant to the Governor General's Agent in the South-West Frontier.†

In the same year the mines were visited by H. Ricketts, Esq., C. S., who proposed to Government that "a small sum be expended in working for a short period in order thoroughly "to test the produce and to show the people of the country how to turn the veins to the "best advantage."

M. Stœhr in the paper printed herewith details the circumstances under which he came out to this country and the steps which led to the formation of the first Singhbhúm Copper Company. Since his return to Europe, this company ceased operations in 1859; and a second, formed on the ruins of its predecessor, lasted only from 1862 to 1864, when it also was dissolved.

In 1857, M. Durrschmidt published a report (with a map) on the "copper mines of Singhbhúm." All the important part of the information is derived from Colonel Haughton and M. Stœhr. Some of the minor details would be of interest only to persons purposing to re-open the works. Speaking generally, this report takes a much more favourable view of the prospects of mining than was justified by the facts available at the time.

In the prospectus of the second or Hindostan (Singhbhúm) Copper Company, a number of analyses and opinions regarding the quality of the ore by various assayers and others are quoted. These or rather a portion of them will be found incorporated in the following pages.

The fact of the copper ores having been worked by the ancients has been above alluded to. It is probable that the greater number of old excavations enumerated in the table on p. 100 are of considerable antiquity. Elsewhere‡ I have discussed the reasons which have led me to the conclusion that the ancient workers were an early Aryan race called *Seraks*.

Within recent years a rude kind of working has been undertaken by the local rajahs and zemindars. But in consequence of poverty of the ore, flooding of the mines, want of labor (the pay perhaps being neither liberal enough nor regularly bestowed), or finally, as has sometimes been the case, sudden discovery on the part of the rajahs that their dignity was being compromised by the work, all such operations have been discontinued.

Geology.—In order to render the following account intelligible, it will be necessary to give a brief sketch of the geology of the district in anticipation of the full account of it, which will be published when the examination of the whole area shall have been completed.

The rocks of Singhbhúm, so far as they have been examined, are referable to two formations. The metamorphic, consisting of granitic and foliated gneiss, schists, &c., and the sub-metamorphic, consisting of slates, quartzites and schists, which latter are sometimes not lithologically distinguishable from those belonging to the metamorphic.

In Manbhúm, exclusive of the coal-fields, something less than four-fifths of the area is occupied by metamorphic rocks. In the remaining fifth at the south of the district the

* Asiatic Researches, vol. 18, p. 170, 1833.

† J. A. S. B., XXIII, p. 103, 1854.

‡ Proc., A. S. B., June 1869, p. 170.

sub-metamorphic rocks are let in by an east and west fault; thence southwards they pass into the district of Singhbhúm, where they cloke round irregular areas of metamorphic rocks. The principal of these areas lies east of the station of Chaibassa. The rocks seen are coarse granitic and porphyritic boss-forming gneisses which are traversed by a perfect network of trap (diorite) dykes. This combination produces a very peculiar effect which, as seen from the top of a high hill, has been aptly compared to a chessboard. The walls formed of trap dykes constitute substantial boundaries between adjoining properties. North and north-west of Chaibassa there is another area of the same metamorphic rocks which is, however, free from trap or nearly so. A third small area exists near Khursowa, regarding which something will be said again further on. The appearance of the sub-metamorphic area is very different from that just described; it is characterised by being traversed by long ranges of hills with deep intervening valleys which correspond to the position of the softer varieties of rock of which the formation is composed.

The copper ores to which this account refers occur for the most part in a zone of schists whose geological position is situated near the base of the sub-metamorphic rocks. These schists form the northern flank of a broken spur of hills which leaving the Chota Nagpúr plateau strikes eastwards for a distance of 40 miles through the estates of the rajahs of Khursowa, Seraikela, and Dhalbhúm, then bending round gradually to south-east and ultimately to south, it disappears under the alluvium of Midnapur.

The principal ranges composing this spur are of quartzite, upon which incrustations of the copper salts are occasionally found; but the ore which has been worked is, with a few exceptions to be noted hereafter, associated only with schists.

Measured along the strike, these copper-bearing rocks extend for a distance little short of 80 miles. Copper ores have not been discovered west of Lopso; but there is no geological reason why they should not be found for many miles further in that direction in the Chota Nagpúr highlands.

In the tables appended an abstract is given of the principal facts which have been observed at the various localities in which the copper has been found. And in the accompanying map all these localities are indicated. M. Stœhr's paper contains all the available reliable information regarding the working of the mines.

The determination of the question as to the manner in which the copper occurs, whether in lodes or as a deposit, is one of no less difficulty than it is of importance. M. Stœhr holds the opinion that it occurs in lodes, though admitting that much may be said in favor of the opposite view. He describes the variable strength of the deposit itself and the interruption and separation of the outcrops which in some places are close to each other. Carrying out this view, he distributes the localities where ore occurs along two lodes which he calls the north and south. He alludes to the fact of the existence of particular beds of rock in the vicinity of the copper showing signs of excessive metamorphism which he considers to be due to local action; but he does not mention that the copper, if followed along its line of strike, is found to penetrate into areas occupied by rocks which are undistinguishable in their lithological characters from the most crystalline rocks occurring in the older series. Of course it may be that these, like the single beds above mentioned, have been affected by local metamorphism, possibly caused by the intrusion of granite, but the granite which occurs is not distinguishable from that which is often found in Bengal to alternate with well foliated rocks, and is therefore believed to be of metamorphic origin. Thus this circumstance, which might otherwise be used as a crucial test of the validity of the lode hypothesis, is itself so uncertain and fraught with doubt that it is a rather dangerous description of evidence to make use of in such a discussion.

In support of the view that the copper partakes of the nature of a mechanical or chemical deposit in the beds, there is the fact that the underlie of the ore as seen at the surface nearly always appears to correspond with the dip of the schists, and that sometimes the schists appear to be permeated throughout with the ore. Adopting this view for the moment, the following supposition would appear to afford a possible explanation of most of the phenómena with regard to the ore, which have as yet been observed. With the original materials of the sandstones and mudstone shales, which subsequently become metamorphosed into schists, the ore may have been either chemically or mechanically deposited. At some period the crushing and tilting up of the rocks, of which there is abundant evidence, produced cracks and possibly openings between adjacent beds, towards which a segregation of the copper particles which until that time were equally disseminated throughout the mass of the schists may have taken place and continued until they became filled with ore and so given rise to the appearances which have been regarded as indicating the existence of lodes. If this view be correct then the highly metamorphosed rocks which occur in the otherwise uninterrupted strike of schists at Akarsuni and Kumerara must be derived from the schists by excessive local metamorphism. But if, on the other hand, these rocks belong to the older metamorphics which they certainly at first sight appear to do, then the lode hypothesis must be admitted to be true.

Reviewing the evidence on both sides, the legitimate conclusion to be drawn would seem to be that the copper of Singhbhúm in all probability occurs both in lodes and as a deposit disseminated throughout the materials which compose the schists. Similar cases of double conditions of occurrence are not unknown in other countries, as will be alluded to again further on.

ORES.

The ores of the upper part, or, as it is technically called the 'back' of the deposit, have all been converted into carbonates and oxides.

In assays made upon eight different qualities of ore by M. R. Schenck, and quoted in the Hindostan Copper Company's prospectus, the contained copper varies between 35·03 per cent. and 1·46 per cent. Three analyses by Messrs. Phillips and Darlington of specimens of carbonates gave the following results:—

No. 1.—Copper	31·5 per cent.	Silver	2oz.	5dwts.	17grs.	per ton of ore.		
No. 2.— "	6·26 "	"	1 "	2 "	20 "	"	"	
No. 3.— "	6·0 "	"	0 "	19 "	14 "	"	"	

Three other specimens were examined by Messrs. Howard and Dollman and gave the following results:—

No. 1.—18·8	per cent. of copper.
No. 2.—21·8	" "
No. 3.—24·0	" "

Three specimens brought by me from Jamjura yielded according to Mr. Tween's analysis—

No. 1.—Jamjura ore, copper	= 52·0 per cent.
No. 2.— " "	= 44·5 "
No. 3.—Dugni "	= 36·5 "

Nos. 1 and 2 were picked specimens, but No. 3 was the ordinary ore to be found at Dugni.

Messrs. Henry Bath & Sons, to whom some of the ores, smelted to a regulus, were sent in 1854, reported as follows:—" Our assayer has carefully tested the samples thou sent us; they contain about 50 per cent. of iron which makes them very difficult to smelt, and is also very prejudicial to their sale; we think, however, that the prices affixed to them may be obtained."

We are thy sincere friends,

HENRY BATH & SONS.*

Mining Office, Swansea, 8mo., 19, 1854.

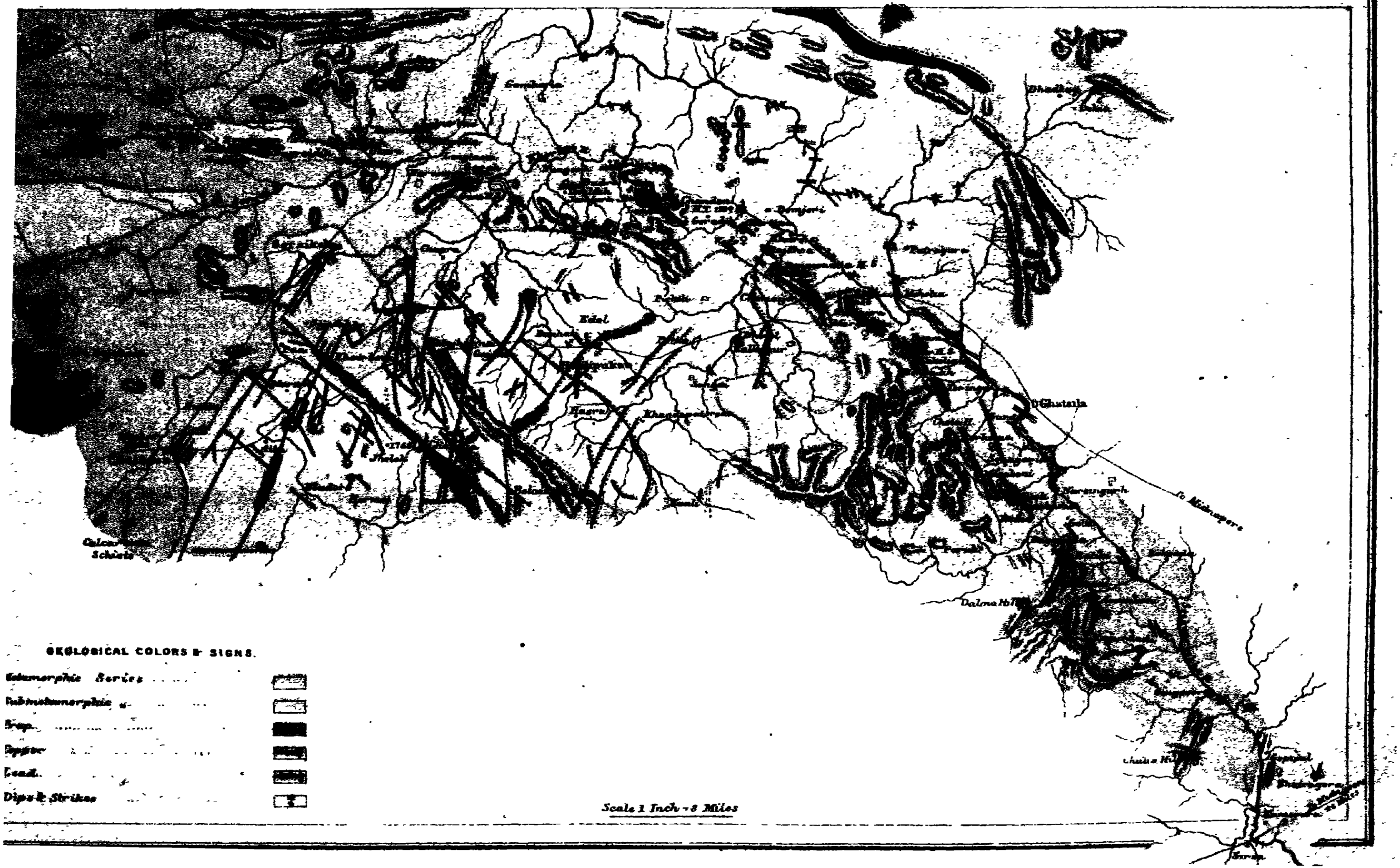
No. 1.—Copper,	42 per cent.	£37	per 21 cwt.
No. 2— "	41 "	35-15	" " "
No. 3.— "	39 "	34-2	" " "
No. 4.— ..	36 ..	31	.. .. ..

The assays above quoted were of the carbonates or of grey-copper.

Copper pyrites occurs in the schists at Rajdoha; it was first found there by the second company; fragments of rock permeated with it are still to be found in the debris. It seems to have been little affected by the weather.

* Proceedings Asiatic Society of Bengal, XXIV, 1855, p. 706.

NOTE.—Of the minerals occurring in the schists, the following are the principal which have been met with: Garnet, Schorl, Kyanite, Chlorite, Tremolite, and Actinolite. In the hill Dari, which is formed of potstone underlying the schists, a peculiar indurated talc occurs in veins. The potstones are extensively quarried, and supply a plate factory in the neighbouring village. At Jamjura M. Stœhr discovered an interesting carbonaceous mineral, of which I also obtained specimens in the refuse heaps when I visited that locality; it is described in the Mining and Metallurgical Journal for 3rd June 1859.


Ghatsila
To Midnapore
Dalma Hill
Calcareous Schists
GEOLOGICAL COLORS & SIGNS.
Metamorphic Series
Submetamorphic
Trap
Copper
Lead
Dips & Strikes
Scale 1 Inch = 8 Miles

Some of the manufactured copper was thus reported on at the Calcutta Mint:—

"Three slabs weighing about 139 lbs.; these were subjected to lamination and proved to be suited in all respects for purposes of coinage. The quality of this metal is excellent, being scarcely inferior to the best, equal to the average and decidedly superior to several shipments of imported copper."

(Sd.) R. BAIRD SMITH,
Mint Master.

As it is almost impossible at the present day, without excavating in the mines to a considerable depth, to obtain more than a few specimens of the carbonates or oxides of copper which lie near the surface or incrust the walls of the galleries, it is most fortunate that we are able to avail ourselves of M. Stœhr's researches and opinions. His presence during the mining operations and subsequent examination of the ores in Europe have afforded him the most favorable opportunities for ascertaining the precise nature of the ores obtainable in the deep mines.

It may be taken as a fact fully established by the analyses quoted above, that exceedingly rich ores of copper do occur in Singhbhúm. Before proceeding to the discussion of the practical question in reference to the possibility of working the ore with profit, it is necessary to allude to the—

METALS IN ASSOCIATION WITH THE COPPER.

It is a matter of the greatest importance to ascertain the proportion of other metals which ordinarily occur associated with the copper. Supposing the ore even not to contain a sufficient quantity of copper to make it pay to extract it alone, it might still, if it included precious metals, be worked with profit. Such is the case with the argentiferous ore or Fahlerz from Eisleben in Prussian Saxony.

In the assays of three specimens of ore by Messrs. Phillips and Darlington quoted above, the ounces of silver per ton of ore vary between 1 and $2\frac{1}{4}$. M. Stœhr found traces, but only traces, of gold and silver; while Mr. Tween did not obtain even a trace in some ores and smelted copper which I brought from Jamjura.

Small quantities of Bismuth were found in some of the ores.

Having in the previous pages pointed out the two-fold manner in which the copper ores occur—both in lodes and in beds—and their quality, the discussion of the practical question whether the ores are such as can be worked with profit in this country may now be entered upon. The facts and collateral circumstances which must influence a decision may be grouped under the following heads:—

I. Character of the ores and their mode of occurrence.

II. Experience of previous miners, ancient and modern.

III. Local circumstances.—Position of mines; Means of communication and distance of marts; Supplies of labor, fuel and lime; Proprietory; Climate.

IV. Comparison with other countries where ores of similar character and occurring in a similar manner have been worked.

I. Although rich ores exist, their mode of occurrence is so capricious and uncertain that working them must necessarily involve an enormous expenditure.

Ores of very much inferior quality if they occurred with a continuous unbroken lead which could steadily be followed up by the miners might, even under various unfavorable conditions existing in Singhbhúm, be worked with profit.

M. Stœhr distinctly speaks of good ore having been found at many points, but in nearly all cases an unusual richness of the deposit proved to be purely local and confined to nests which were speedily worked out, and unremunerative copper-permeated schist met with further down.

II. Many of the ancient mines have been so thoroughly worked out that it is often impossible to find more than mere particles of carbonate incrustations.

It may be argued with an apparent amount of plausibility that the ancient mines, their number and extent, indicate a prosperous condition of the industry at some former period. We do not, however, know under what circumstances they were worked. In the early times to which they seem chiefly to belong, copper may have possessed a value relative to the precious metals much higher than it does at present. And, again, although it may have paid parties of natives to work with their simple furnaces which could without loss be relinquished when the supply of ore failed and others be erected in a new locality, we cannot feel assured that it would prove proportionally profitable to a European Company, whose chief prospect of success would depend on the possibility of applying machinery for the extraction and reduction of the ore continuously in one place.

With regard to the experience gained by the companies, beyond M. Stœhr's and M. Durrschmidt's papers, there seems to be now no accessible information. Without being able to refer to the records of either of the companies, it is impossible to form any estimate of what their working expenses amounted to.

Copper was manufactured during the time of the second company and forwarded to Calcutta, but what proportion its price in the market bore to the cost of its production I have been unable to ascertain.

M. Stœhr's opinions on the first company and on the proposition to form a second are printed herewith. He concludes that notwithstanding the disadvantages, some of the old mines might be worked profitably, but for that purpose so colossal a company* was not suited. But *moderate expectations*, such as M. Stœhr speaks of, are not generally sufficient to attract speculators and capitalists; and a really economical enterprise such as might easily be carried out on the continent of Europe is scarcely practicable here.

III.—Local circumstances.—*Position of Mines.* On all sides the range in which the copper ores occur is surrounded by broken hilly country, which is drained by a number of rivers of sufficient dimensions to seriously impede traffic during the rainy season.

The only made road in the vicinity of the mines is the one between Chaibassa and Midnapur. It is unprovided with bridges: the portion of it in Singhbhúm and Dhalbhúm alone is (May 1869) in fair condition.

In reference to the roads, Colonel Haughton, who was anxious to represent the prospects of a mining enterprise in the most favorable light possible, wrote:—"From the diggings at Kumerara† there is a good road only 85 miles in length to Tumlook. The distance "from Landu or Jamjura to the Cossye river at Dhee Kulliánpúr is about 70 miles; and that "river might, it seems probable, be available for water carriage during short periods in the "rains, as the Damúda is at points far above those where it is ordinarily navigable. There "is every facility for the construction of a good road to Dhee Kulliánpúr or to Midnapur, "and in fact there was formerly a Government route in nearly the same direction. * * * "The distance from Tumlook *viâ* Midnapur would be about 132 miles." The copper which was made in 1862-64 was not despatched by either of these routes but *viâ* Purulia to Raniganj, the distance of which place from Landu being 130 miles, and the roads little better than cart tracks.

Should the proposed direct line of railway *viâ* Midnapur to Bombay be opened up, the copper mines will probably be rendered much more accessible than they are at present.

Labour.—Coolies can be obtained in abundance. The Chota Nagpur Dhangas were found to be the best workmen.

Fuel.—The supply of wood to be obtained in the immediate neighbourhood is limited, and a few years would exhaust the timber on the hills composed of the copper-bearing rocks. There is, however, a considerable amount of heavy timber on the rises to the Chota Nagpur plateau.

The discovery of coal at Midnapur is a fact which may prove favorable to the prospects of working the copper with profit.

Lime.—The only lime which was used for fluxing the ore was manufactured from 'kunkur.' No hope of any more regular or economical source can be held out at present. Some calcareous schists do, indeed, exist near Chaibassa, but in them the quantity of other minerals mixed up with the carbonate of lime is so great as to make it doubtful whether they could be successfully burnt for lime.

* The capital of the 2nd or Hindostan Copper Company was £120,000 in 24,000 shares.
† The most eastern locality.

Proprietory.—Singhbhúm proper belongs to several members of the Porahat family, of whom the principal are the Koer of Seraikela and the Thakúr of Khursowa; they both give service to Government as Magistrates, but pay no tribute whatever for their estates. The Dugni Baboo in whose lands copper also occurs is a cadet of the same family.

In the estate of the Rajah of Dhálbhúm, the remainder of the copper localities, including those at Landu and Rajdoha, are situated.

The first company, confident in the productiveness of the mines, agreed according to M. Stœhr to pay the Rajahs of Seraikela and Dhalbhúm Rs. 9,200 for the right to mine. In the prospectus of the second company the annual rent is stated to be Rs. 4,500. A considerable portion of this rent for the years while operations were being carried on is still due. Acting on a decree of the Singhbhúm Deputy Commissioner, the Rajah of Dhalbhúm has seized the houses and engine of the company at Rajdoha; but the former have already fallen to pieces, and the latter uncared for and neglected will soon become worthless.

Climate.—The climate of Singhbhúm is decidedly unhealthy; this point is one of no small importance where a number of Europeans might have to be employed. I have been informed that the employés of the two copper companies suffered much from fever. My own experience is, that natives of India, especially men from the north-west, suffer excessively from fever in Singhbhúm; of course both Europeans and natives might, to a certain extent, become acclimatized, as has happened in other parts of India.

IV.—Examples are not wanting in other parts of the world where ores of similar character and mode of occurrence to those of Singhbhúm have been worked, with which a brief comparison may be usefully instituted.

Copper Mines of Eisleben.—At Eisleben in Mansfeld, Prussian Saxony, the ore of copper extracted permeates a schist (Kupferschiefer) which can be worked with as much regularity as a coal seam.* Notwithstanding the perfection of the machinery and the comparative ease with which the ore is extracted, it is a fact that the copper is manufactured at a loss. "Every ton of refined copper as it leaves the works has actually cost more than an equal weight of metal could be purchased for on the spot from the merchant."

The profits of these great and unique mines (which more or less directly support 60,000 people) are nearly all derived from the small proportion of silver which occurs in the ores and is extracted during the process at but little additional cost. The magnitude of the operations and the immense quantities of the copper ore which are smelted alone enable the work to be carried on with profit.

In the copper ores of Singhbhúm silver does sometimes occur as is shown by the assays on page 96. But the amount is so small that it is extremely doubtful whether it could be extracted with profit.

It has been stated that *for the most part* the underlie of the ores in Singhbhúm corresponds with the dip of the schists; but it can scarcely be said of them, owing to their steep inclination and irregular lateral extension, that they could be 'worked like a coal seam.'

South-West of Ireland.—In the south and south-west of Ireland copper ores occur disseminated throughout a zone of Devonian sandstones; for a long time it was doubted whether true metalliferous lodes existed, all the copper being supposed to occur "as a mechanical deposit derived from the waste and destruction of some original mineral vein district."† Recent deep mining operations which have been carried on with success have proved the existence of true lodes.‡ Thus there would appear to be a double mode of occurrence of the ore there, similar to that which has been supposed to be the case in Singhbhúm.

In the preceding pages the object sought after has been to give a simple statement of facts, from which those who may be interested will doubtless draw their own conclusions.

In mining operations such as would be necessary in Singhbhúm so much depends upon the regularity with which the ore occurs that no one could with any confidence venture to predict the result of excavation on a large scale.

Courageous enterprise guided by the best professional skill in mining has both its triumphant successes and its heavy losses and disappointments: until underground exploration has extended much further in Singhbhúm, it will be uncertain which fate awaits those who may at any future time venture upon copper mining in that district.

* These mines are fully described in a paper by Mr. Jervis, Jour. Soc., Arts, vol. IX, 1860-61.
† Memoirs of Geological Survey of Great Britain and Ireland, explanations to sheets 200, 203, and pp. 278.
‡ Geological Magazine, vol. VII, No. 5, p. 241.

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhúm.	1	Madhopur, 3 miles north of Kumerara.	2	Outcrop excavations ...	......
	2	Hills, W. of Asunbuni	Numerous ...	Ditto ...	40° E. N. E.
	3	Hills, S. E. of Badia	......	.. ...	......
	4	Badia	Very numerous ...	Ditto and shafts ...	40° to E. 25° N.
	5	Mosabuni	Numerous ...	Outcrop excavations ..	Ditto ...
	6	Surda	12	Ditto ...	?
	7	Hills, W. & W. N. W. of Surda ...	Numerous ...	Quarries, shafts, inclines	40°
	8	Hills, W. of Teringa & Kondadih ...	Ditto ...	Outcrop excavations & inclines.	30°-35° E. N. E.
	9	Sideshur Hill, S. of Ruam... ...	3 or 4	Ditto & shafts ...	35° N. E.
	10	Mahadeo Hill	......	......	......
	11	Baghghura	Several ...	Inclines ...	......
	12	Hills, S. & S. W. of Matigara (=Raga of Dr. Stœhr).	Numerous ...	Ditto & shafts ...	N. E.
	13	Rangamatti Hill, S. E. corner, N. of Banjo.	1	Shaft	......
	14	Rajdoha a	1	Incline and adit ...	.....
		Ditto b	1	Incline	25° N. N. E.
		Ditto c	1	Shaft	Ditto ...
		Ditto d	1	Incline	Ditto ...
	15	Matku	1	Shaft	......
	16	Hurtopa	1	Ditto	......
	17	Hitku	1	Ditto	......
	18	Landu Barut-ghur Hill	Numerous ...	Shafts, inclines, adit, trench.	35°—, 55° to 10° E. of N.

OF SINGHBHÚM.

No.	Ore.	Rock.	REMARKS.
1	Traces of carbonate: a specimen yielded according to Col. Haughton 24¾ p. c. of copper.	Quartz and black mica-schist, strike 10° E. of N., granite close by.	These mines are full of water, to remove which and renew excavation would be necessary before the condition of the ore could be ascertained.
2	No traces of ore *in situ* ...	Black and grey mica-schists ...	Slag close by, indicating that ore was once found.
3	......	......	This locality is given by M. Stœhr.
4	Traces of carbonates abundant.	Grey and black mica-schists, strike 25° W. of N. Towards Mosabuni gneissose rocks strike more to north.	The relative positions of the Badia excavations indicate four distinct outcrops of ore. The principal of these passes through the village of Badia, near which are great heaps of slag. This was evidently a centre of extensive operations.
5	Ditto.		
6	No trace of ore at present exposed.	Schists.	
7	Incrustations of the carbonates on the walls.	Black mica-schist	From the abundance of slag it would appear that here, as at Badia, considerable quantities of ore must have been smelted by the ancients.
8	Traces of carbonates rare ...	Mica-schist.	
9	Ditto slag abundant ...	Ferruginous mica-schist ...	At the site of the old town of Ruam, there are several tanks covered up by jungle and immense quantities of slag.
10	......	......	This locality is given by M. Stœhr.
11	Ditto ...	Mica-schist.	
12	Ditto ...	Ditto	A number of deserted potstone mines and some which are still worked occur along this range.
13	Traces of carbonates ...	Ditto & quartzite ...	Incrustations of the carbonates and black oxides occur on the quartzites forming the main axis of the hill.
14	Ditto .	Slaty blue schists . . .	These are situated on a spur of Rangamatti.
	Ditto ..	Ditto ...	These were worked by the Copper Company. But the pyrites was only just reached a short time before working was discontinued; d is west of the river, b and c being to the east.
	Copper pyrites	Ditto ...	
	Traces of carbonates ...	Ditto ...	
15	Carbonates, traces of red copper and pyrites.	Greenish talcose schist and quartzo-felspathic grit.	
16	No ore seen	Quartzite.	
17	Traces of carbonates ...	Schist and quartzite	Originally commenced by the ancients; it was deepened by the Company, but has subsequently become filled up.
18	Ditto ...	Quartz and mica-schist much contorted and baked. Banded jaspery quartzites close by.	A considerable amount of ore appears to have been obtained here by the Company. M. Stœhr's papers give the details of workings carried on at Landu.

COPPER ORES OF

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhúm.		Landu Chundra Hill b	Numerous ...	Inclines	35°, 55° to 10° E. of N.
		Ditto Hill, N. of Turamdih c	Ditto .	Ditto	40°—50° N., or 10° E. of N.
		Ditto Hill, N. of Tulsa d ...	Ditto ..	Ditto and adit ...	40° N.
Koer of Seraikela.	19	Jeling { gora ... ... / bera ... ... }	2	Shaft and incline	?
	20	Jamjura (*Tschamtschura* of M. Stœhr)	Several ...	Shafts ..	.
	21	Gura	0	.	.
	22	Tamba—dungri	6 ?	Shafts . ..	25 N.
	23	Saldih	1	Ditto ..	N. N. W. 50°
	24	Múndrú	1	.	N. N. E. 40°
	25	Dúgni	0	0	60° N.
	26	Ukri	1	Outcrop excavation	,,
	27	Komulpur (Banksai)	1	Ditto	?
Thakúr of Khursowa.	28	Akarsúni a	Several	Ditto .	N. W.
		,, b	1	Ditto .	?
	29	Podumpur	2	Ditto	?
	30	Regadih	4 (a-d)	Ditto	?
	31	Lopso Hill	1	Ditto .	40° N.

SINGHBHÚM,—*(Continued)*.

No.	Ore.	Rock.	Remarks.
	Traces of carbonates ..	Schist.	
	Ditto .	Contorted talcose quartzite and micaceous schists.	These works were chiefly made by the Company, but all along the outcrop of the schists there are ancient excavations. In one place the ore permeates 6' of rock.
	Ditto	Ditto	The mines here were worked by the Company.
19	Ditto ..	Talcose and mica-schist.	
20	Ditto and grey copper.	..	These shafts were worked by the Company; one of them fell in while the operations were going on.
21	Traces of carbonates ...	Schist	No mines opened at this locality.
22	Ditto ...	Sandy and fibrous mica-schists	Shafts in very irregular positions and without reference to the lie of the deposit.
23	No trace of ore ..	Mica-schists.	
24	Ditto ..	Soft satiny felspathic and talcose schist.	Said to have been excavated by the father of the present Baboo of Dugni, Rungit Singh.
25	Traces of carbonates .	Mica-schists	This is situated in the village of Dugni; there has never been any excavation.
26	Ditto abundant, a specimen yielded 36·5 per cent. of copper.	White talcose mica-schists and granitic gneisses.	Said to have been worked with profit by the Dugni Baboo about three years ago.
27	Ditto ...	Schists and gneiss.	
28	Traces of carbonate .	Schists, granitic gneiss and trap close by.	A series of excavations in the fields are nearly filled up with surface soil.
	Ditto .	Ditto.	
29	Ditto	Mica-schists and quartz .	Rocks much covered; no strike apparent.
30	Ditto ...	Micaceous and quartzose schists, also gneiss and trap close by (c).	Copper is said to have been manufactured from ore extracted from (d) twelve years ago.
31	Ditto ...	Coarse mica-schists	Situated at foot of the hill west of Kanrudih.

V. BALL,
Geological Survey of India.

METEORITES.—During the past quarter we have received an addition of four specimens of meteorites, representing 3 falls, of which no specimens existed in the Calcutta collections previously.

1st.—From DR. TSCHERMÁK, the present zealous Director of the Mineral Cabinet at Vienna, came a very perfect, though not large, specimen of the fall at Hessle, near Upsala, which took place on the 1st of January 1869. And a very good specimen of the remarkable stone-fall which took place at Kernouve, Napoleonville, Morbihan, France, on the 23rd May 1869. 2ndly, from PROFESSOR DAUBREE, Paris, we have received a fine specimen of the meteoric iron from Deesa, Chili, peculiarly interesting, not only for the breccia-form structure which it presents (recalling the Tula fall), but for the occurrence in it of very well marked crystals of *Enstatite, colourless and transparent* and of a purity not hitherto met with, also crystals of *Peridot*, of *Schreibersite*, and of a lamellar substance closely allied to *Hypersthene*. And also a second smaller specimen of the Kernouve (or Cleguerec) fall of the 23rd May 1869. These were all in exchange for specimens of Indian falls.

T. O.

DONATIONS TO MUSEUM.

From COLONEL H. C. JOHNSTONE we have received a box of fossils collected by him in the Sulyman Range. There has not been time as yet to examine these in detail.

ACCESSIONS TO LIBRARY

FROM 1ST JULY TO 30TH SEPTEMBER 1870.

Titles of Books. *Donors.*

ANDRÆ, DR. CARL JUSTUS.—Vorwerltliche Pflanzen, 2nd Heft. 4to., 1869, Bonn.

BERENDT, DR. G.—Geologie des Kurischen Haffen und seiner Umgebung, 4to., 1869, Königsberg.

BIGSBY, JOHN J.—Flora and Faunna of Silurian Period *(Thesaurus Siluricus)*, 4to., 1868, London.

BENEDEN, VAN, AND GERVAIS, PAUL.—Osteographie des Cétacés Vivants et Fossiles, Livn. 8, 8vo., and Atlas, 4to., Paris.

BOSQUET, J.—Monographie des Crustaces fossiles du Terrain Crétacé du Limbourg, 4to., 1854, Haarlem. THE AUTHOR.

BOURGUIGNAT, J. R.—Histoire Malacologique de la Regence de Tunis, III, 4to., 1868, Paris.

COQUAND, H.—Monographie du genre *Ostrea*, Terrain Crétacé, Text, 8vo., Atlas, Folio, 1869, Marseilles.

DECHEN, DR. H. V.—Begleitworte zur Geologischen Karte von Deutschland, 8vo. and 4to., 2 sheets, 1870, Berlin.

ENGELHARDT, H.—Flora der Braunkohlen formation in Königreich Sachsen (Gekronnt Preiss-schriften), 8vo. and 4to., 1870, Leipzig.

FRESENIUS, DR. C. R.—Qualitative Chemical Analysis, 8vo., 1869, London.

GRAEFFE, DR. EDW.—Reisen im innern der Insel Viti-Levu. 4to., 1868, Zurich. ZURICH NAT. HIS. SOC.

GOULD, A. AUGUSTUS.—Report on the invertebrata of Massachusetts, 8vo., 1870, Boston.

HESSENBERG, FRIED.—Mineralogische Notizen, New Series, pt. 6, 4to., 1870, Frankfort.

HAIDINGER, W. R. VON.—Das Kaiserlich-Konigliche-Montanistiche Museum und die Freunde der Naturwiss., 8vo., 1869, Wien. THE AUTHOR.

HAMY, DR. E. T.—Precis de Palæontologie Humaine, 8vo., 1870, Paris.

HANLEY, S., AND THEOBALD, WM.—Conchologia Indica, pt. I, 4to., 1870, London.

ISSEL, ARTURO.—Malacologia del Mar Rosso., 8vo., 1870, Pisa.

LINNARSSON, J. G. O.—On some Fossils found in *Eophyton* sandstone at Lugnas in Sweden, 8vo., 1869, Stockholm. THE AUTHOR.

LUBBOCK, SIR JOHN.—On the origin of the civilization and primitive condition of man 8vo., 1870, London.

MENZEL, PROF. AUGT.—Die Biene in ihren Beziehungen zur Kulturgeschichte und ihr Leben im Krieslaufe des Jahres. 4to., 1869, Zurich.
ZURICH NAT. HIS. SOC.

MUIR, J.—Sanskrit Texts, Vol. V, 8vo., 1870, London. GOVT. OF INDIA.

MAYER, CHAS.—Catalogue Systématique et Descriptif des fossiles des Terrains Tertiaires, 8vo., 1870, Zurich.

NORDENSKIÖLD, A. E.—Sketch of the Geology of Spitzbergen, Roy. 8vo., Stockholm.
THE AUTHOR.

ON the existence of rocks containing organic substances in the fundamental gneiss of Sweden, 8vo., 1870, Stockholm. THE AUTHOR.

QUETELET, A.—Observations des phenomenes periodiques pendant les annees, 1865, et 1866, (Extrait du Tom. XXXVII des Memoires Acad. Roy. de Belgique), 4to. THE AUTHOR.

OOSTER, W. A., UND C. VON FISCHER.—*Protozœ Helvetica*, Bd. II, Abth. I, 4to., 1870, Basle and Geneva.

PERRIN, ANDRE.—Etude Prehistorique sur la Savoie, specialement a l' epoque lacustre, 8vo. Atlas, 4to., 1870, Chambery.

PICTET, F. J.—Materiaux pour la Palæontologie Suisse, ou Recueil de Monographies sur les Fossiles du Jura et des Alpes, Ser. V, pts. 7 and 8, 4to., 1870, Geneva.

SCHIMPER, W. PH.—Palæontologie Vegetale ou la Flore de Monde Primitif, 2nd Tom. pt. I, with Atlas, 4to., 8vo., 1870, Paris.

SANDBERGER, DR. F.—Land und Süsswasser Conchylien der Vorwelt., Roy. 4to., 1870, Wiesbaden.

TSCHERMAK, G. Von.—Der Meteorit von Lodrau, Aus dem LXI, Bde. de Sitzb. d. k. Akad. d. Wissensch. April Heft. 1870, Wien. THE AUTHOR.

ZITTEL, A.—Palæontographische Mittheilungen, Aus d. Museum, K. Bayerischen staates (II. 2). Die Fauna der æltern Cephalopoden, fuhrenden Tithonbildungen, pt. I, text, 8vo., pl. fol. xxv—xxxii, 1870, Cassel.

PERIODICALS, &c.

Abstract of results of hourly meteorological observations taken at the Surveyor General's Office from January to April and May 1870, 8vo., 1870, Calcutta.

American Journal of Science and Arts, Vol. XLIX, Nos. 145 and 146, 8vo., 1870, New Haven.

Annales des Sciences Géologiques, Tom. I, 8vo., 1870, Paris.

Annals of Indian Administration, Vol. XIV, pt. 1, 8vo., Serampore. GOVT. OF INDIA.

Annals and Magazine of Natural History, Vols. 5 and 6, Nos. 30, 31, and 32, 4th Series, 8vo., 1870, London.

Bastian, A. W. Hartmann, R.—Zeïtschrift für Ethnologie, Jahrg. II., Heft. 2, 8vo., 1870, Berlin.

Cuyper, Ch. de. Revue Universelle des Mines, de la metallurgie, des travaux publics, &c., &c., *14th year, Tom. XXVII, pt. 2, 8vo., 1870.

Geological Magazine, Vol. VII, Nos. 6 & 7, 8vo., 1870, London.

Indian Economist, with Superintendent and Reporter, Vol. I, Nos. 11, 12, folio, 1870, Calcutta.

Indian Economist, with Superintendent and Reporter, Vol. II, Nos. 1, 2, folio, 1870, Calcutta.
GOVT. OF INDIA.

Journal de Conchiliologie, Series 3, Tom. X, No. 3, 8vo., 1870, Paris.

Mineral Statistics of Victoria for the years 1868-69, 4to., 1868-69, Melbourne.
DEPT. OF MINES, VICTORIA.

Neues Jahrbuch für Mineralogie, Geologie, and Palæontologie, Jahrg., 1870, 2nd Heft., 8vo., Stuttgart.

Palæontographica, Vol. XIX, pt. 3, 4to., 1870, Cassel.

Petermann, A.—Geographische Mittheilungen, Bd. XVI, 5, 6, 7, 4to., 1870, Gotha.

Pfeiffer, Dr. Louis. Malako-Zoologische Blätter, Bds. 16, 17, 8vo., 1870, Cassel.

Professional papers on Indian Engineering, Vol. VII, No. 28, 8vo., 1870, Roorkee.
MAJOR MEDLEY, R. E.

Quarterly Journal of Microscopical Science, New Series, No. XXXIX, 8vo., 1870, London.

Quarterly Journal of Science, No. XXVII, July, 1870, 8vo., 1870, London.

Römer, Dr. Edou. Novitates Conchologicæ, Suppl. III, Lief. 24, 25, 4to., 1870, Cassel.

Records of the Geological Survey of India, Vol. III, pt. 3, 8vo., 1870, Calcutta. THE SURVEY.

Reports of the Mining Surveyors and Registrars for 1867-68-69 and 1st quarter of the year 1870, Melbourne. DEPT. OF MINES, VICTORIA.

GOVERNMENT SELECTIONS, &c.

INDIA.—Budget Estimate for the year 1870-71, fol., 1870, Calcutta. GOVT. OF INDIA.

" General Report on the Topographical Surveys of India, 1868-69, fol., 1870, Calcutta. GOVT. OF INDIA.

" List of Civil Officers holding gazetted appointments under the Government of India on 1st January 1870, 8vo., 1870, Calcutta. GOVT. OF INDIA.

" Selections from the Records of the Government of India, Home Department, No. LXXVII. Papers relating to the Nicobar Islands, 8vo., 1870, Calcutta. GOVT. OF INDIA.

BENGAL.—General Report on Public Instruction in the Lower Provinces of the Bengal Presidency for 1868-69, with appendices, 8vo., 1870, Calcutta.
GOVT. OF BENGAL.

BOMBAY.—General Report of the Administration of the Bombay Presidency for 1868-69, 8vo., 1870, Bombay. GOVT. OF BOMBAY.

" Selections from the Records of Bombay Government, 8vo., Bombay. DITTO.

BRITISH BURMAH.—Annual Report on Civil and Criminal Justice of Rangoon and Moulmein for 1869, 8vo., 1870, Rangoon.
GOVT. OF BRITISH BURMAH.

" Report on Trade and Customs of British Burmah, 1868-69, 8vo., 1870, Rangoon. GOVT. OF BRITISH BURMAH.

" Revenue Report, British Burmah, for 1868-69, 8vo., 1870, Rangoon.
GOVT. OF BRITISH BURMAH.

" Report on Public Health and Vital Statistics for 1869 of British Burmah, 8vo., 1870, Rangoon. GOVT. OF BRITISH BURMAH.

N. W. PROVINCES.—Selections from the Records of Government, North-Western Provinces, Vol. III, Nos. 3, 4, 8vo., 1870, Allahabad.
GOVT. OF N. W. PROVINCES.

OUDH.—Report on Dispensaries and Lunatic Asylums in the Province of Oudh, fls., 1869, Lucknow. GOVT. OF OUDH.

" Report upon the Administration of Criminal Justice in the Province of Oudh, fls., 1869, Lucknow. GOVT. OF OUDH.

" Report upon the Administration of Civil Justice in the Province of Oudh, fls. 1869, Lucknow. GOVT. OF OUDH.

" Report on Sanitation and Vaccine for the Province of Oudh, 1869, fls., Lucknow.
GOVT. OF OUDH.

OUDH.—Report upon the progress of Education in the Province of Oudh, 1869, fls., Lucknow. GOVT. OF OUDH.

„ Report on Census Table, No. V, of Oudh, Vol. I, with map, &c., fls., 1870, Lucknow. GOVT. OF OUDH.

PUNJAB.—Report on the Administration of the Punjab and its dependencies for 1868-69. GOVT. OF PUNJAB.

„ Selections from the Records of the Punjab Government, New Series IV. Administration of Bhawulpúr, Chumba, and Patowdie States, 8vo., 1870. GOVT. OF PUNJAB.

„ Selections from the Records of the Punjab Government, New Series VI. Sanitary Survey of Villages watered by the Western Jumna Canal, 8vo., 1870. GOVT. OF PUNJAB.

TRANSACTIONS OF SOCIETIES.

BERLIN.—Zeitschrift der deutschen Geologischen-gesellschaft, Berlin, Bd. XXI, Heft. 1-4, 8vo., 1869. GERMAN GEOLOGICAL SOCIETY.

„ Zeitschrift der deutschen Geologischen-gesellschaft, Berlin, Bd. XXII, Heft. 1, 2, 8vo., 1870. GERMAN GEOLOGICAL SOCIETY.

„ Monatsberichte der K. Preussischen Akad. der Wissenschaftlichen, 8vo., May, 1870, Berlin. THE ACADEMY.

BRUSSELS.—Memoires de l' Acad. Royale des sciences des lettres, &c., de Belgique, Tom. XXXVII, 4to., 1869. BELGIAN ACADEMY.

„ Bulletin de l' Acad. Roy. des Scien. de Belgique, 2me. Ser., Tom. XV, XVI, 1868. BELGIAN ACADEMY.

„ Annuaire de l' Acad. Roy. des Scien. de Belgique, 8vo., 1869. DITTO.

CALCUTTA.—Journal of the Asiatic Society of Bengal, pt. II, Nos. 2—3, 8vo., 1870, Calcutta. THE SOCIETY.

„ Proceedings, Asiatic Society, Bengal, Nos. 6, 7, 8, 1870, 8vo. ASIATIC SOCIETY OF BENGAL.

„ Journal of the Agricultural and Horticultural Society of India, Vol. II., pt. 1, 8vo., 1870, Calcutta. THE SOCIETY.

CANADA.—Canadian Journal of Science, Literature, and History, Vol. XII, No. 5, 8vo., 1870, Toronto. CANADIAN INSTITUTE.

DRESDEN.—Sitzungs-berichte der Naturwissensch. Gesellschaft, Isis, Nos. 1-3, January to March, 1869, 8vo. THE SOCIETY.

FLORENCE.—Bolletino. R. Comitato Geologico d'Italio, pt. 6, 8vo. DITTO.

GÖTTINGEN.—Abhandlungen der Konigl. Gesellschaft der Wissenschaften zu Göttingen, Bd. XL, 4to., 1869.

„ Nachrichten von der K. Gesells. der Wissenschaften und der Georg-August Universitat, 12mo., 1869. THE SOCIETY.

„ Astronomische Mittheilungen von der Königl. Sternwarte zu Gottinque, 1869, 1 Thiel., 4to. THE SOCIETY.

KÖNIGSBERG.—Schriften der Königl. physikalisch-economische Gesellschaft zu Königsberg, Jahrg, 1869, pt. 2, 4to.

LONDON.—Philosophical Transactions of Roy. Soc., No. 158, pts. 1, 2, 4to.

„ Proceedings of Royal Society of London, Vol. XVIII, 119-121, 8vo. THE ROYAL SOCIETY.

„ Quarterly Journal of the Geol. Society of London, Vol. XXVI, pt. 2, No. 102, 8vo., 1870. THE GEOLOGICAL SOCIETY.

„ Journal of the Society of Arts, Vol. XVIII, Nos. 912-923, 8vo. THE SOCIETY.

„ Journal of the Royal Asiatic Society of Great Britain and Ireland, Vol. IV., pt. 2, 8vo., 1870, London. THE SOCIETY.

„ Proceed. of Roy. Geographical Soc., Vol. XIV, No. 2, 8vo. DITTO.

MUNICH.—Abhandlungen der Mathematisch-physikalischen classe d. Königl. Bayerischen Akad. der Wissenschaften, Vol. X, Abth. 2, 4to., 1868.
THE BAVARIAN ACADEMY.

„ Sitzungs-berichte der Königl. Bayerischen Akad. der Wissenschaften zu München, 8vo.

1867, Heft. II, Nos. 3, 4.
1868, „ I, „ 1, 4.
1868, „ II, „ 1, 4.
1869, „ I, „ 1, 4. THE BAVARIAN ACADEMY.

„ Beobachtungen des Meteorologischen observatoriums, auf dem Hohen Treissenberg, von 1851-64, Supplt. VII, 8vo., 1868.
THE BAVARIAN ACADEMY.

„ Resultate der München Meteorologischen Beobachtungen, 1857-66, Supplt. VI, 8vo., 1868. THE BAVARIAN ACADEMY.

„ Verzeichniss von 6323 telescopischen Sternen, Supplt. VIII.
THE BAVARIAN ACADEMY.

NEUCHATEL.—Bulletin de la Soc. des Sciences Nat., Tom. VIII, pt. 2, 8vo., Neuchatel.
THE SOCIETY.

NEW YORK.—First Annual Report of the American Museum of Natural History, January, 1870, 8vo. THE MUSEUM.

PALERMO.—Giornale di Scient. Natural. ed Econom. del Consiglio di Perfezionamento di Palermo, Vol. I, pts. 1-4, 1865.—Vol. II, pts. 1-4, 1866.—Vol III, pts. 1-4, 1867.—Vol. IV, pts. 1-4, 1868, 4to. THE INSTITUTION.

PHILADELPHIA.—Transactions of the American Philosophical Society, Vol. XIII, pt. 3, 4to.
THE SOCIETY.

„ Proceedings of ditto ditto, Vols. X, XI, 1868-69, 8vo. THE SOCIETY.

„ Journal of Franklin Institute, Vol. LIX, Nos. 3 –6, 8vo., 1870.
THE INSTITUTE.

STOCKHOLM.—Kongliga Svenska Vetenskaps Akademiens Handlingar, Ny följd, 1864, Bd. V, Heft. 2.—1865, Bd. VI, Heft. 1.—1866, Bd. VI, Heft. 2.—1867, Bd. VII, Heft. 1. THE SWEDISH ACADEMY.

„ Öfversigte af Kongl. Vetenskaps Akademiens Förhandlingar, 1865, XXII—1866, XXIII—1867, XXIV—1868, XXV.
THE SWEDISH ACADEMY.

„ Meteorologiska Jakttagelser Sverige, 1864, VI—1865, VII—1866, VIII, 4to.
THE SWEDISH ACADEMY.

„ Lefnadsteckningar öfver Kongl. Svenska Vetensk. Akad., Bd. I, Heft. 1, 1869.
THE SWEDISH ACADEMY.

„ Kongliga Svenska Fregatten Eugenies resa omkring Jorden, 1851-53, Heft. XII, Zoologi. 6, 4to. THE SWEDISH ACADEMY.

ST. PETERSBURGH.—Bulletin de l'Academie Impériale des Sciences de St. Petersburg, Tom. XIV, Nos. 5, 6, 4to., 1870.

VIENNA.—Verhandlungen der k. k. Geologischen Reichs-Anstalt, 1869, Nos. 1—18, 8vo.
THE INSTITUTE.

„ Jahrbuch der k. k. Geologischen Reichs-Anstalt, Bd. XIX, Heft. 1—4, 1869, 8vo.
THE INSTITUTE.

„ Sitzungsber. d. Kaiserl. Akad. der Wissenschaften, abtheil. 1, Bd. LVIII, 1—5, 1868; abtheil. 2, Bd. LVIII, 2—5; abtheil. 1, Bd. LIX, 1—11, 1869; abtheil. 2, Bd. LIX, 1—3. THE ACADEMY.

ZURICH.—Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich Jahrg. XII, pts. 1—4, 1867, Jahrg. XIII, pts. 1—4, 1868, 8vo. THE SOCIETY.

RECORDS

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ABSTRACT OF RESULTS OF EXAMINATION OF THE AMMONITE-FAUNA OF KUTCH, WITH REMARKS ON THEIR DISTRIBUTION AMONG THE BEDS, AND PROBABLE AGE, by WILLIAM WAAGEN, PH. D., *Geological Survey of India.*

IN preparing for the "Palæontologia Indica" a monograph of the fossil Cephalopoda and in particular of the AMMONITIDÆ, represented in the Kutch Jura, I have obtained some general results, which may be interesting to notice in connection with the study of the jurassic deposits in that province.

The Cephalopoda seem rather common in all the principal jurassic strata of Kutch, excepting in the lowest beds, which have as yet furnished only some Gastropods, a great number of Pelecypods, besides some undeterminable fragments of Belemnites and a few other fossils.

The number of species of *Ammonites* collected by Messrs. Blanford, Wynne, and Fedden, in the course of a few working seasons, amounts to about 80, of which number, however, all are not in a sufficiently good state of preservation to allow of accurate determination. According to the different genera, which have been lately distinguished in supercession of the old genus "*Ammonites*," the following are represented in the Kutch Jura: 5 species of *Phylloceras*, 2 of *Lytoceras*, 1 *Haploceras*, 6 *Oppelia*, 6 *Harpoceras*, 7 *Peltoceras*, *(n. g.)* 4 *Aspidoceras*, 17 *Stephanoceras*, and about 32 *Perisphinctes*. If we inquire into the geological distribution of those genera in the European jurassic districts, we will find that the *Phylloceras* and *Lytoceras* are not limited to certain strata of the jurassic formation, but begin in the Trias, and extend without any interruption into the middle, and even upper layers of the Cretaceous period. *Haploceras*, on the contrary, occurs within narrower limits, appearing solitary for the first time in the Bathonian, and disappearing again in the lowest beds of the Neocomian, its principal development being in the Tithonian group. Of the genus *Oppelia* the greatest number of species is found in Oxfordian and Kimmeridgian beds, furnishing only a few sporadic species in lower strata, and beginning in the Inferior Oolite. *Harpoceras* is characteristic for the Lias, but extends, however, in well developed forms up into the Oxfordian, and even into the Kimmeridgian group. *Peltoceras* is chiefly an Oxfordian, *Aspidoceras* chiefly a Kimmeridgian and a Tithonian genus. *Stephanoceras* occurs through the whole Jura, whilst *Perisphinctes*, represented by a larger number of species and specimens than any of the other genera, is mostly characteristic for the Upper Jura.

If we now consider the number of species, by which every single genus is represented in the Kutch Jura, the simple comparison of the numbers before given, with the facts known regarding the geological position of the genera in Europe as stated above, will show us clearly, that at least a part of those jurassic strata must belong to the Upper Jura, unless we presume that the faunæ have followed laws of distribution quite different from those which were prevalent during the time of the jurassic deposits in Europe.

Proceeding to the species, I will give brief distinctive characters of the new forms which I have described. There are of *Phylloceras*, preserved in the Geological Survey Museum,—

Phylloceras disputabile, Zitt. (golden oolite of Keera hill near Charee; brown oolite of the Jooria hills).
" *Lodaiense*, Waagen, n. sp. (brown oolite of Lodai).
" *Feddeni*, Waagen, n. sp. (oolite with iron nodules near Dhosa).
" *ptychoicum* Quenst. (coarse iron sandstone of the Katrol range).
" *Zignodianum*, Orb. (golden oolite of Keera hill).

Phylloceras Lodaiense, Waagen, n. sp. Very closely allied to *Phyll. disputabile*, Zitt., but the furrows disappearing on the siphonal side and very deep near the umbilical margin; it has also much shorter and broader lobes than *Phyll. disputabile.*

Phylloceras Feddeni, Waagen, n. sp. Closely resembling *Phyll. Homairei*, Orb., but the umbilicus a little smaller and the external saddle finishing in three unequal leaves. It differs from *Phyll. euphyllum*, Neum., by a little larger umbilicus and less developed third leaf on the external saddle.

The genus *Lytoceras* has furnished, as stated before, only two species, one of them being new; they are:

Lytoceras Adeloides, Kudern. (golden oolite of Keera hill).
" *rex*, Waagen, n. sp. (sandy yellow rock, S. of Charee).

Lytoceras rex, Waagen, n. sp. A specimen of 600 m m. in diameter. Inner whorls finely striated without any prominent ribs; body-chamber with a few prominent ribs, with broad smooth spaces between them; ribs with 7 folds on each side.

The species of *Haploceras* which I have mentioned before is not determinable with sufficient certainty, as the last part of the body-chamber is wanting; but it is very probably

Haploceras tomephorum, Zitt. (coarse sandy iron rock, S. of Boojooree).

The genus *Oppelia* has furnished several well known European species of great interest, only two new forms were among the number. The species are:

Oppelia subcostaria, Opp. (golden oolite, Keera hill).
" *glabella*, Leckenby (gray marl nodule, Keera hill).
" *trachynota*, Opp. (coarse sandy iron rock, Katrol range).
" *Cutchensis*, Waagen, n. sp. (same layer and locality).
" *plicodiscus*, Waagen, n. sp. (rock indistinct, S. of Madapoor).
" cf. *serrigera*, Waagen (gray limestone, S. of Nurrha).

Oppelia Cutchensis, Waagen, n. sp. Very much like *Oppelia compsa*, Opp., however much smaller; the siphonal side rounded, granulated; tubercles on the body-chamber scarce, distant, rounded; ribs entirely disappearing.

Oppelia plicodiscus, Waagen, n. sp., belonging to the group of *Oppelia subtililobata*, W. and nearly allied to *Opp. tenuilobata*, Opp. The shell is small and covered with rather broad, strongly falciform ribs, which are a little swollen at the middle of the sides; near the siphonal margin a great number of very fine, short ribs, which are not in connection with the others, are visible.

Among the species of the genus *Harpoceras*, there is a single European form; all the other species are as yet known only from the Indian Jura. The species are:

Harpoceras hecticum, Rein. (golden oolite, Keera hill).
„ *ignobile*, Sow. (yellow limestone, Keera hill).
„ *crassefalcatum*, Waagen, n. sp. (same layer and locality).
„ *Orientale*, Orb. (rock indistinct, Keera hill).
„ *fornix*, Sow.
„ *Nurrhaënse*, Waagen, n. sp. (iron nodule, Nurrha).

Harpoceras crassefalcatum, Waagen, n. sp., resembles very much *Harp. ignobile*, Sow., but the whorls are depressed; the ribs much stronger, less numerous and much more irregular; the species is also of smaller size, when adult.

Harpoceras Nurrhaënse, Waagen, n. sp. Allied to *Harp. lunula*, Rein., but the ribs which cover the sides of the shell are much finer and sharper, and much more curved than in the last mentioned species.

Peltoceras, Waagen, n. gen. This genus is, I consider, very closely allied to *Aspidoceras*, Zitt., and possibly only a sub-genus of it. It is established for the species which Zittel in his last volume on the Tithonian fauna has separated from his genus and united with *Perisphinctes*, but I think the relation between those forms believed to belong to *Perisphinctes* and *Aspidoceras perarmatum*, as he calls this Ammonite, are much closer than the relations between them and the true *Perisphinctes*, though contractions of the whorls also occur in the former species. I am disposed to consider in this case the form of the lobes as the most important distinguishing character. Thus, for instance, in *Amm. Arduennensis* and *Amm. perarmatus*, the lobes are nearly identical in both species, the first lateral lobe being so much enlarged that the second lateral lobe becomes nearly obsolete; and as this form of lobes never occurs in the true *Aspidoceras* (as *Asp. iphicerum* and others) nor in the true *Perisphinctes* (as there the auxiliary lobes have another position), I think it reasonable to separate those species with this particular shape of lobes under a distinct generic designation. The genus *Peltoceras* is, therefore, characterised by the *particularly enlarged lateral lobe, a discoid, largely umbilicated shell; the whorls sometimes with contractions, always covered with strong straight ribs, which are sometimes provided with two or three rows of spines; siphonal side more or less flattened or even excavated, ribs crossing over or disappearing before they reach the siphonal part of the shell. Aperture more or less rectangular.* Thus characterised, I believe, the genus should include the groups of *Pelt. Arduennense, transversarium, perarmatum, hybonotum* and a few other, less known, forms. The species of this genus occurring in the Kutch Jura are:

Peltoceras athleta, Phill. (gray marl nodule, N. of Goodjinseer).
„ *aegoceroides*, Waagen n. sp. (brown oolite of the Jooria hills).
„ *Arduennense*, Orb. (same layer and locality).
„ *semirugosum*, Waagen, n. sp. (brown oolite of Lodai and the Jooria hills).
„ *bidens*, Waagen, n. sp. (same layer and locality).
„ *perarmatum*, Sow. (brown oolite of Lodai and Jooria, and doubtful from the red sandy iron rock of Kuntkote).
„ *monacanthus*, Waagen, n. sp. (coarse yellow sand rock, Katrol range).

Peltoceras aegoceroides, Waagen, n. sp. A very small species, with many thin somewhat rounded whorls and numerous simple ribs which cross the siphonal side undivided; whorls barely touching each other.

Peltoceras semirugosum, Waagen, n. sp. This species becomes extremely large, and in that form closely resembles *Pelt. perarmatum*, Sow. Young specimens, however, have almost entirely the form of *Pelt. Arduennense*, Orb., with the single difference, that the ribs, which are, as long as they exist on the shell, divided into two branches nearly from the umbilical margin, are stronger and less numerous. Growing larger each rib is produced at the point, where it passes from the lateral to the siphonal side, into a prominent spine, from which the rib proceeds regularly over the siphonal side. In yet larger specimens a second row of spines appears also near the umbilical margin, the ribs become then nearly obsolete, and fragments are only distinguishable from *Pelt. perarmatum* by the peculiar flattening of the ribs which connect the corresponding tubercles of both the umbilical and perispherical rows.

Peltoceras bidens, Waagen, n. sp. Very much resembling the former species, but distinguishable by the ribs being mostly undivided and very coarse; they are provided on the siphonal side with two indistinct tubercles. Large specimens have more distant spines than *Pelt. semirugosum*.

Peltoceras monacanthus, Waagen, n. sp. Allied to *Pelt. hybonotum*, Opp., but with only one row of spines near the umbilical margin, and less distinct granulations on both sides of the median excavation on the siphonal side.

The genus *Aspidoceras*, though represented in our Museum by a good many fragments, has furnished only two determinable species; they are:

Aspidoceras iphicerum, Opp. (red, fine sandy iron rock, N. of Dhosa).
,, *Wynnei*, Waagen, n. sp. (coarse sandy iron rock, at Toodoora, S. of Boojooree, together with *Hapl. tomephorum*) in the highest layer containing *Ammonites*).

The other fragments are from the coarse iron sandstone of the Katrol range, and appear to be referable to *Asp. iphicerum*, Opp., and *binodum*, Quenst.

Aspidoceras Wynnei, Waagen, n. sp. Most nearly allied to *Asp. Apenninicum*, Zitt., but the outer row of tubercles stronger, and more numerous; and in general more irregular than in the species just quoted.

The genus *Stephanoceras* is extremely rich in forms in the Kutch Jura, but notwithstanding this, it only represents there a single group, the Macrocephali. Several sub-divisions among the species belonging to the genus can be distinguished, facilitating the determination of the species themselves. I distinguish (1) a group of species, allied to the true *St. macrocephalum*, (2) a group of species with bent ribs on the siphonal side, which replace in India the group of *St. goverianum*, &c., of Europe, (3) the group of *St. modiolare*, represented in India but by a single species.

To the first group belong the following species:

Stephanoceras macrocephalum, Schloth. (golden oolite of Keera hill, brown oolite of Jooria, grayish yellow marl rock of Jumara).
,, *tumidum*, Rein, (golden oolite, Keera hill).
,, *Polyphemus*, Waagen, n. sp. (common in the brown oolite of Lodai, Jooria and N. of Goodjinseer, very rare in the golden oolite of Keera hill).
,, *lamellosum*, Sow. (golden oolite, Keera hill; ? yellow sand rock, N. of Dhosa).
,, *Chareeënse*, Waagen, n. sp. (golden oolite, Keera hill; yellow marl rock, Jumara).
,, *Grantanum*, Opp. (same rocks and localities as the preceding sp.; also in a sandy iron rock at Kaora, Putchum).
,, *elephantinum*, Sow. (brown oolite, Lodai).
,, *arenosum*, Waagen, n. sp. (same rock and locality).
,, *? Maya*, Sow. (red iron rock, Kuntkote).

Stephanoceras Polyphemus, Waagen, n. sp. This species grows enormously large, 1½ feet in diameter, and seems identical with d'Orbigny's drawing of *St. tumidum* (Orb. non Rein.). It differs from the real *St. tumidum* by very broad rounded ribs and a smooth body-chamber, while Reinecke's species has fine sharp ribs and a plicated body-chamber.

Stephanoceras Chareeënse, Waagen, n. sp. Allied to *St. Morrisi*, Opp., but much broader near the umbilicus and with a very narrow siphonal side, on account of which the transversal section of the whorl is nearly triangular. There are also some differences in the sutures.

Stephanoceras arenosum, Waagen, n. sp. Of a very flat lenticular form, with faint, broad rounded ribs somewhat resembling *St. Lalandeanum*, Orb., but the ribs are not undivided, and only few of them reach to the umbilical margin. The lobes are also quite different.

The second group includes the following species:

Stephanoceras dimerum, Waagen, n. sp. (golden oolite, Keera hill; gray marl rock, Jumara; sandy iron rock, Kaora; doubtful, Jooria).
" *subtrapezinum*, Waagen, n. sp. (golden oolite, Keera hill).
" *eucyclum*, Waagen, n. sp. (brown oolite, Keera hill, Jooria hills).
" *opis*, Sow. (iron nodules, Keera hill; brown oolite, Jooria; oolite, Dhosa).
" *fissum*, Sow. (red iron rock, Kuntkote; brown oolite, Lodai, Jooria; oolite, Dhosa; iron nodule, Keera hill).
" *Nepalense*, Gray (red iron rock, Kuntkote; brown sandstone, Trummo river).

Stephanoceras dimerum, Waagen, n. sp. Allied to *St. Herveyi*, Sow., but with smaller umbilicus and with the ribs curved in front on the siphonal side. The ribs are broad and prominent; the general shape of the specimens somewhat globular. Body-chamber with strongly curved, high, lamellose ribs. The species attains scarcely more than a diameter of 50-60 m m.

Stephanoceras subtrapezinum, Waagen, n. sp., very much like the preceding species, but with much finer ribs, and with flattened sides of the whorls; the aperture having a somewhat trapezoidal shape and the form of the whole shell being more lenticular. It attains a little larger size than the preceding species.

Stephanoceras eucyclum, Waagen, n. sp. Full grown specimens with preserved body-chamber have a slight resemblance to similarly preserved specimens of *Cosmoceras ornatum* or *Duncani*, but the examination of the inner whorls shows that the species belongs to *Stephanoceras*. The umbilicus is very wide, the whorls a little compressed, and covered with polytome fine ribs; the lobes are very short and broad.

The last group of *Stephanoceras* is that of *Steph. modiolare*, Luid., only represented in Kutch by a single species.

Stephanoceras diadematum, Waagen n. sp. (golden oolite: Keera hill).

Stephanoceras diadematum, Waagen, n. sp. The species attains nearly one foot in diameter. Full grown specimens are entirely smooth, and closely resemble large individuals of *St. modiolare*, Luid., except that the umbilicus is always wider; small specimens, however, are entirely different, as they never have the "Lamberti-like" shape, which characterises young individuals of the last mentioned species. *St. diadematum* has always very broad, depressed whorls, which are covered in the first youth with dichotome ribs becoming afterwards polytome, and passing with a slight curvature in front over the flat siphonal side; the lateral lobes are situated on this latter portion of the shell.

The genus *Perisphinctes* has furnished, of all the Ammonites, the greatest number of species, and I regret that the European species of this genus are as yet so little known, that in many cases a comparison of our fauna with the forms found in European strata becomes utterly impossible. The forms of *Perisphinctes* found in Kutch may be conveniently divided into a few larger sections, which I may call after the oldest and best known species, without, however, assigning these sections the value of developmental series (Formenreihen, Entwickelungsreihen). I distinguish (1). *A section of forms, related to Per. Königi*, Sow.; the species to which I refer represent a connecting link between the last mentioned species and *Per. Rolandi, Frischlini*, and other Ammonites of the European Upper Jura. The whole section ranges between the true *Perisphinctes* and *Stephanoceras*, and, following the external form, it could almost with equal right be referred to the one or the other of the two genera. (2). *Section of forms allied to Per. Martiusi*, Orb. The species of this section chiefly occur in middle Jurassic and Callovian beds, and their number was recently considerably increased by the description of new forms in Europe. The latest representatives of it in Europe are known from Oxford strata. (3). The species of this section are *allied to Per. plicatilis*, Sow., and are chiefly from Oxfordian and Kimmeridgian beds. (4). *Section of forms allied to Per. Rehmanni*, Opp. A small series of species with a very peculiar shape, in many points entirely separated from all the other *Perisphinctes*, and chiefly characteristic for the Callovian. Besides these there occur in the Kutch-Jura also some other species which cannot be referred to any of those sections, and which must for the present be looked upon as sporadic, or isolated species.

The first section, characterised by the great scarcity of contractions on the whorls, mostly without any umbilical edge, and by thick scarce ribs, includes the following species from Kutch:

Perisphinctes obtusicosta, Waagen, n. sp. (oolite of Dhosa; iron nodules of Keera hill; gray marl nodules, N. of Goodjinseer).
„ *angygaster*, Waagen, n. sp. (same rocks and localities as preceding species).
„ *Dhosaënsis*, Waagen, n. sp. (oolite of Dhosa; brown oolite of the Jooria hills; iron nodule, Keera hill).
„ *mutans*, Waagen, n. sp. (dark red iron rock, N. of Goodjinseer).

Perisphinctes obtusicosta, Waagen, n. sp. Slightly resembling *Per. Rolandi*, Opp., but with less numerous and rounder ribs, which are not divided so far down as in the last mentioned species; in large specimens the ribs become flatter and more numerous. The lobes are much finer and more ramified than in *Per. Rolandi.*

Perisphinctes angygaster, Waagen, n. sp. In its general form resembling *Per. involutus*, Quenst., but with only dichotome ribs, which are few in number and obtusely rounded; in some places there is a broad, flat, contraction of the whorl visible. The lobes are very much like those of the preceding species.

Perisphinctes Dhosaënsis, Waagen, n. sp. A small species of about 40 m m. in diameter, with wide umbilicus, rounded whorls and very strong dichotome ribs, which often become a little broader in passing over the siphonal side, resembling the ribs in some *Aegoceras* or in *Amm. fissicostatus*, to which latter species our specimens have a certain resemblance as regards their general form. The lateral margins of the aperture have two not very long lancet-shaped ears. The species seems to be common.

Perisphinctes mutans, Waagen, n. sp. Young specimens of this species have a certain resemblance to *Per. Dhosaënsis*, but the form changes even at an early stage: the whorls become compressed, the ribs flattened, and the body-chamber of a specimen of 60 m m. in diameter (about the largest size the species appears to attain) is nearly quite smooth.

The section of *Per. Martiusi* is represented in the Kutch Jura by nine determinable and at least four, as yet undeterminable, species, the latter being in our Museum only indicated by fragments, not sufficient for a reliable definition of the species. The better known species belonging to this section are:

Perisphinctes spirorbis, Neum. (golden oolite, Keera hill).
" *bracteatus*, Neum. (same beds and locality).
" *funatus*, Opp. (same beds and locality).
" *paramorphus*, Waagen, n. sp. (same beds and locality).
" *arcicosta*, Waagen, n. sp. (same beds and locality).
" *curvicosta*, Opp. (oolite of Dhosa; marl nodules, Goodjinseer; yellow marl rock, Jumara).
" *euryptychus*, Neum. (hard yellow limestone, Keera hill).
" *Pagri*, Waagen, n. sp. (red iron rock, Kuntkote).
" *Gudjinsirensis*, Waagen, n. sp. (marl nodules, Goodjinseer).

Perisphinctes paramorphus, Waagen, n. sp. A remarkable species, which undergoes great changes according to age. When quite young, the whorls are rounded and slightly involute, covered with strong, few, and dichotomous ribs; middle sized specimens have a slightly squarish section of the whorls, these being more involute and covered with moderately numerous, strong bipartite ribs. Growing only a little larger than 100 m m. in diameter the whorls become rather high oval with a narrowly rounded siphonal side, and the ribs disappear entirely; in this stage the species resembles large specimens of *Per. spirorbis*.

Perisphinctes arcicosta, Waagen, n. sp. An intermediate species between *Per. aurigerus*, Opp., and *curvicosta*, Opp. The whorls are compressed like those in the former species, whilst the kind of ribbing agrees more with that of the latter. The largest size to which the species attains is about 60—70 m m. in diameter. In such specimens the body-chamber is but slightly ribbed and the lateral ribs are disconnected from those situated on the siphonal side.

Perisphinctes Pagri, Waagen, n. sp. In its general form very nearly allied to *Per. Orion*, Opp., but with less strongly prominent and more numerous lateral ribs; the ribs on the siphonal side are slightly turned backwards.

Perisphinctes Gudjinsirensis, Waagen, n. sp. A species also belonging to the group of the Convoluti, but certainly one of the most extraordinary forms of the whole group. The whorls are very depressed and the umbilicus large. Young specimens are of the usual habit, but fuller grown ones become provided with high, distant lateral ribs, which are divided into three flat branches on the depressed siphonal side. Full-grown specimens do not exceed a diameter of 100 m m.

In connection with the few last mentioned forms I shall describe three species, which are as yet unknown from European jurassic formations, and which are, strictly speaking, more geologically than zoologically related to the former. They are:

Perisphinctes frequens, Opp. (oolite of a valley, west of Soorka hill, together with *Rhynch. myriacantha*).
" *denseplicatus*, Waagen, n. sp. (same layer and locality).
" *aberrans*, Waagen, n. sp. (white marl rock, Keera hill).

Perisphinctes denseplicatus, Waagen, n. sp. Very nearly allied to *Per. frequens*, Opp., but with a somewhat smaller umbilicus, higher whorls, and much finer lateral ribs, which are never tripartite on the outer margin, but sometimes bipartite and sometimes cross undivided over the siphonal side.

Perisphinctes aberrans, Waagen, n. sp. The only species with which I can compare this form is *Per. Albertinus*, Cat., but the difference lies in Catullo's species possessing a furrow on the siphonal side when young, while there is no trace of it in the present species. The dissimilarity, however, between young and old specimens of *aberrans* is by no means less marked than in *Per. Albertinus*. The young form resembles a little *Per. convolutus;* it has many separate rounded whorls, with fine ribs and tolerably numerous very oblique contractions of the whorls. When growing larger the ribs of the individual become in an equal degree more distant, stronger and higher on the sides of the whorls, whilst, on the contrary, they gradually disappear on the siphonal side.

The third section (of *Per. plicatilis*, Sow.) is the richest in forms in the whole Jura. In Europe it is represented by at least 100 species, all occurring in strata of Oxfordian, Kimmeridgian or Tithonian age, but for the greater part the species are as yet undescribed. The difficulty, therefore, not only in determining, but in comparing the Indian species with European forms, is much greater in this section than in any other, and the conclusions, which in other groups and genera are so naturally associated merely with their names, can in this instance not be drawn from the identity of the species, but only from the general habitus of the forms; however, some of the Indian species can nevertheless be identified with European Ammonites. The species belonging to this section are:

Perisphinctes Indogermanus, Waagen, n. sp. (brown oolite, Jooria hills; yellow marl rock, Joorun).
" *plicatilis*, Sow. (red iron rock of Kuntkote; same rock at Joorun).
" *torquatus*, Sow. (coarse iron sandstone of the Katrol range).
" *bathyplocus*, Waagen, n. sp. (same layer and locality).
" *Pottingeri*, Sow. (same layer and locality).
" *euplocus*, Waagen, n. sp. (same layer and locality).
" *Katrolensis*, Waagen, n. sp. (same layer and locality).
" *virguloides*, Waagen, n. sp. (red iron rock of Kuntkote).

Perisphinctes Indogermanus, Waagen, n. sp. Very nearly allied to *Per. plicatilis*, Sow., and often mistaken for this species, but distinct from it by rounded whorls and flattened ribs on the siphonal side. There are specimens in our museum from Kutch as well as from Trouville in Normandy (Zone of *Am. cordatus*).

Perisphinctes bathyplocus, Waagen, n. sp. Allied to *Per. torquatus*, Sow., so much so that young specimens are almost undistinguishable. *Per. bathyplocus* has, however, always finer ribs and thicker whorls. When large, the lateral parts of the ribs are much swollen and distant from each other, and to each of them correspond five or six fine ribs on the siphonal side; only in very large specimens the latter become obsolete, or very nearly so.

Perisphinctes euplocus, Waagen, n. sp. Allied to *Per. Pottingeri*, Sow., but with much thinner whorls, and S-shaped, irregular, fine ribs. On the body-chamber the ribs become scarcer, more prominent and straight.

Perisphinctes Katrolensis, Waagen, n. sp. Equally allied to *Per. Pottingeri* as the last, but attaining a much larger size, and with the body-chamber much less strongly ribbed.

Perisphinctes virguloides, Waagen, n. sp. Closely resembles *Per. virgulatus*, Quenst; the ribs are, however, not so fine and the contractions of the shell indistinct.

The next species belongs to a group which is of great importance for the geology of the European Jura: it is—

Perisphinctes leiocymon, Waagen, n. sp. (red iron rock of Kuntkote).

The group is typified by *Per. polyplocus*, Rein. This latter species is known in Europe to be very characteristic for the Kimmeridgian, and not alone that, but the whole group is restricted to a similar horizon. It is doubtful whether in India the geological position is exactly the same, but nevertheless *Per. leiocymon* deserves particular notice.

Perisphinctes leiocymon, Waagen, n. sp. Closely allied to *Per. polyplocus*, Rein., but with much fainter ribs and of by far larger dimensions; only the ribs are near the umbilical margin somewhat more strongly marked. The species shows also by its rounded ribs some slight resemblance to *Per. albienus*, Opp., and thus the Indian species may be said to represent a connecting link between the section of *Per. Martiusi* and the *Polyploci* group.

The last section of *Perisphinctes* is that of *Per. Rehmanni*, Opp. The species belonging to it usually possess spiny whorls and a flat band along the middle of the siphonal side. Though I think the section originates with *Per. sulcatus*, Hehl., I quote as the first species *Per. Rehmanni*, because the geological relations between those two species have not as yet been established. The Indian species belonging to the section are:

Perisphinctes Rehmanni, Opp. (golden oolite, Keera hill).
„ *anceps*, Rein. (iron nodules, Keera hill; oolite, Dhosa).
„ *arthriticus*, Sow. (iron nodules, Keera hill).
„ *Jooriensis*, Waagen, n. sp. (brown oolite, Jooria hills).

Perisphinctes Jooriensis, Waagen, n. sp. Allied to *Per. Balderus*, Opp., but more evolute, with less numerous contractions on the whorls and sharper and more regular ribs.

The 73 species above enumerated have been determined and described from the materials in our Museum with sufficient certainty. Several forms I was obliged to put aside, partly because the materials were in bad preservation, and partly because there was not a sufficient number of specimens existing, in order to point out the exact relations or distinctions of the species; this is particularly the case among the *Perisphinctes*.

The oldest known locality where Ammonites occur, and at the same time the richest in forms, is the Keera hill near Charee, and the mineralogical differences of the rocks in which different species are preserved clearly indicate that there must be several distinct groups of middle and upper jurassic strata exposed. This variety of the rocks cannot be accidental, as is, for instance, shown by *St. tumidum* or *Per. funatus*, which never occur in an iron nodule, while *Per. arthriticus* has never been found in the golden oolite. Of the different beds in this locality, containing different Ammonite-faunas, I can at present point out two, each with a sufficiently large number of species, the golden oolite and the bed with iron nodules; all the other strata are represented only by a few species:—

(1.) Ammonites of the *Golden Oolite* of *Keera hill* near Charee:

Phylloceras disputabile, Zitt.
„ *Zignodianum*, Orb.
Lytoceras Adeloides, Kud.
Oppelia subcostaria, Opp.
Harpoceras hecticum, Rein.
Stephanoceras macrocephalum, Schloth.
„ *tumidum*, Rein.
„ *Polyphemus*, Waagen.
„ *lamellosum*, Sow.
„ *Chareënse*, Waagen.
Stephanoceras Grantanum, Opp.
„ *dimerum*, Waagen.
„ *subtrapezinum*, Waagen.
„ *diadematum*, Waagen.
Perisphinctes spirorbis, Neum.
„ *bracteatus*, Neum.
„ *funatus*, Opp.
„ *paramorphus*, Waagen.
„ *arcicosta*, Waagen.
„ *Rehmanni*, Opp.

Of these species *Ph. disputabile*, Zitt., *Zignodianum*, Orb., and *Lyt. Adeloides*, Kud., are known to be characteristic in the mediterranean province of the jurassic formation of Europe for a group of strata beginning with Bathonian and most probably terminating with lower Oxfordian rocks. The following species indicate a much more narrowly limited horizon: *Steph. macrocephalum*, Schloth., *tumidum*, Rein., *Grantanum*, Opp., *Perisph. spirorbis*, Neum., *bracteatus*, Neum., *funatus*, Opp., and *Rehmanni*, Opp., all without exception in the central European province are highly characteristic for the lower Kellovian beds, or the "zone of *St. macrocephalum*" of Oppel. The Ammonite-fauna of the 'Golden Oolite' shows very little resemblance to the faunas of other localities, and in fact there are only three species which are common to this layer and the brown oolite of Lodai and the Jooria hills; those are *Phyll. disputabile*, *St. macrocephalum* (very rare at Lodai), and *Polyphemus* (very rare at Keera hill). It seems to me that the characteristic species of the Ammonite-fauna of this Golden Oolite appear again only at Kaora in Putchum, and at Jumara, though similar rocks may be often represented in different horizons throughout the Kutch jurassic territory.

2). Ammonites of the *Iron nodules* of *Keera hill* near Charee—

Stephanoceras opis, Sow.
 " *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
 " *angygaster*, Waagen.
 " *Dhosaënsis*, Waagen.
 " *anceps*, Rein.
 " *arthriticus*, Sow.

The greater part of these species also occurs at the two next localities, and I shall, therefore, quote those occurring in the two latter immediately following.

(3). Ammonites of the *Oolite* of *Dhosa*—

Stephanoceras opis, Sow.
 " *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
 " *angygaster*, Waagen.
 " *Dhosaënsis*, Waagen.
 " *curvicosta*, Opp.
 " *anceps*, Rein.

(4). Ammonites of the dark-gray *marl nodules*, *Goodjinseer*—

Peltoceras athleta, Phill.
Perisphinctes obtusicosta, Waagen.
 " *angygaster*, Waagen.
 " *curvicosta*, Opp.
 " *Gudjinsirensis*, Waagen.

There is, I think, but little doubt that the Ammonite-fauna of these three localities indicates very closely the same geological horizon, particularly when we consider the small number of specimens (there are in our Museum not more than about 60 specimens preserved from all the three localities) which were examined, and that these have furnished so many identical species.

Of the species noticed, the following are found in the European Jura: *Pelt. athleta*, *Perisph. anceps* and *curvicosta*; all three are most characteristic forms of the upper Kelloway strata.

The next localities which have furnished a greater number of species are Lodai and the Jooria hills. The rock containing the fossils is a very fine, often sandy dark-brown oolite with much iron, and the Ammonite-fauna of both places, is so very closely allied that it will not be necessary to quote the species separately.

(5). Ammonites of the "*Brown oolite*" of *Lodai* and the *Jooria hills*—

Phylloceras disputabile, Zitt.
„ *Lodaiense*, Waagen.
Peltoceras aegoceroides, Waagen.
„ *Arduennense*, Orb.
„ *semirugosum*, Waagen.
„ *bidens*, Waagen.
„ *perarmatum*, Sow.
Stephanoceras macrocephalum, Schloth.
Stephanoceras Polyphemus, Waagen.
„ *elephantinum*, Sow.
„ *arenosum*, Waagen.
„ *eucyclum*, Waagen.
„ *fissum*, Sow.
Perisphinctes Dhosaënsis, Waagen.
„ *Indogermanus*, Waagen.
„ *Jooriensis*, Waagen.

Of *Phyll. disputabile* I have already mentioned the geological position; among the other species in the list it may seem a little strange to find together, apparently in the same layer, *St. macrocephalum* and *Pelt. perarmatum*. The discrepancy may be explained in two ways. Either there exist in Lodai and Jooria two layers of very similar lithological aspect, but of different age, or *St. macrocephalum* had in India a greater vertical distribution than in Europe, that is, the species passes in India from lower into higher strata, during the deposition of the latter of which it was already extinct in Europe. The latter explanation seems to me the more plausible one, because there occurs also in another locality, at Kuntkote, a species of the *Macrocephali*, (*St. Maya*, Sow.,) which is so closely allied to *St. macrocephalum*, that it is hardly possible to distinguish them specifically, and also because in Kutch the *Macrocephali* group in general seems to continue, in a great variety of forms, into higher beds than is the case in Europe. Under these circumstances, we may, therefore, consider as the most valuable species for determining the age of the strata above noticed the species of the *Peltoceras*, which in Europe are highly characteristic for lower and middle Oxfordian. The most important species are *Peltoc. Arduennense* and *perarmatum*, and next to these *Per. Indogermanus*, which is very common in the "zone of *Am. cordatus*" of the "Vaches noires."

The brown oolite has, in common with the oolite of Dhosa, *Steph. opis* and *fissum*, whilst on the Keera hill we again find *St. eucyclum* in an indurated yellow limestone, together with *Per. euryptychus*, Neum., which possibly could represent the brown oolite in that place.

The locality west of Soorka hill has furnished only two species of Ammonites—

Perisphinctes frequens, Opp., and
„ *denseplicatus*, Waagen,

associated with *Rhynch. (Hemithyris) myriacantha*, Desl., in a brown oolite, very much like that of Lodai.

The next locality of considerable geological interest is that of Kuntkote, because Sowerby has described from there several species, and among them *Per. calvus*, which was most probably wrongly identified with one occurring in Europe; but unfortunately no specimen of true *A. calvus*, Sow., is found among our materials. The rock of Kuntkote is dark-red, fine sandy, ferruginous, much impregnated with salt and gypsum. The species are—

(6). Ammonites of the *red ferruginous rock* of *Kuntkote:*

Peltoceras cf. *perarmatum*, Sow. (possibly *Pelt. Oegir*, Opp.)
Stephanoceras Maya, Sow.
„ *fissum*, Sow.
„ *Nepalense*, Grav.

Perisphinctes Pagri, Waagen.
„ *plicatilis*, Sow.
„ *virguloides*, Waagen.
„ *leiocymon*, Waagen.

These few species can serve merely by their general character as a guide towards the determination of the age of the Kuntkote beds, because the only species of which the geological position is well known in Europe, *Per. plicatilis*, indicates only generally strata of lower or middle Oxfordian age. The other forms of *Perisphinctes* occurring at Kuntkote resemble in general character such species as, if found in Europe, would be referred to the middle or upper Oxfordian. This and the appearance of the rock leads me to believe that the Kuntkote beds are a little younger than the brown oolite, with which they have only a single species, *St. fissum*, in common. A similar rock to that of Kuntkote occurs only at a certain distance north from Dhosa, where *Aspidoceras iphicerum*, Opp., has been found in a dark-red and a slightly sandy ferruginous rock.

The last locality of importance which has furnished nearly the greatest number of specimens of Ammonites, though the number of species is not very large, is the Katrol range, the rocks there being represented chiefly by coarse ferruginous sandstones and sandy ferruginous concretions, with frequent occurrence of fossil wood. The species found there are—

(7). Ammonites of the coarse *ferruginous sandstone, Katrol range:*

Phylloceras ptychoicum, Quenst.
Haploceras cf. *tomephorum*, Zitt.
Oppelia trachynota, Opp.
„ *Cutchensis*, Waagen.
Peltoceras monacanthus, Waagen.
Aspidoceras Wynnei, Waagen.
„ 2 sp. indet.
Perisphinctes torquatus, Sow.
„ *bathyplocus*, Waagen.
„ *Pottingeri*, Sow.
„ *euplocus*, Waagen.
„ *Katrolensis*, Waagen.

The first three species are European forms, and two of them, *Phyll. ptychoicum* and *Hapl. tomephorum*, are very characteristic for the Tithonian formation of the Mediterranean Jurassic province, whilst *Opp. trachynota* occurs in the middle and upper Kimmeridge and Tithonian layers of the Mediterranean and Central European provinces. Of the other species, only *Pelt. monacanthus* and *Asp. Wynnei* have a decidedly Tithonian character, whilst among the *Perisphinctes*, the absence of the group of *Per. polyplocus* also indicates very high jurassic beds. It should also be mentioned that Mr. Fedden notes on the label accompanying the specimens of *Asp. Wynnei* and *Hapl.* cf. *tomephorum*— "From the highest beds containing *Ammonites.*"

Recapitulating briefly what I have said regarding a few of the principal localities containing *Ammonites*, it seems clear (1) that at different places there are strata of a different mineralogical character represented; (2) that these strata contain species of *Ammonites* mostly peculiar to themselves; and (3) that these species indicate distinct geological horizons.

If we take only those species into consideration which occur in the Kutch, as well as in the European Jura, we find that in the golden oolite of Keera hill there are nine species of the "zone of *St. macrocephalum*;" in the oolite of Dhosa and the equivalent beds there are three species of the "zones of *Perisph. anceps* and *Pelt. athleta;*" in the brown oolite are three species of the "zone of *Am. cordatus*" and one of the "zone of *St. macrocephalum.*" In the ferruginous rock of Kuntkote there is one species common to the "zones of *Am. cordatus* and *Pelt. transversarium;*" and, lastly, in the coarse sandstone of the Katrol range are two species of the Tithon-formation and one common to middle and upper Kimmeridgian and Tithonian.

If, therefore, the faunas have not in their development in India followed other laws than they did in Europe, we might arrange the deposits of the whole of the Kutch Jura in the following manner:

Rocks.		Localities.	Probable equivalents in Europe.
Ferruginous sandstone	coarse ...	Katrol range	Tithonian and Upper Kimmeridgian.*
	fine ...	Kuntkote	Upper Oxfordian.
Oolite		Lodai and Jooria	Lower Oxfordian.
		Dhosa	Upper Kelloway.
		Golden oolite ... ... Keera hill.	Lower Kelloway.
Flaggy, sandy limestone and yellow sandstone		Guddera (Ammonites wanting) ...	Bathonian.

The most general division we could at present introduce into the Kutch Jurassic deposits is to separate them into two complex groups of sandstones, divided from each other by a zone of oolites of comparatively small thickness.

But there remains yet the great question, what is Mr. Wynne's "Upper Jura of Kutch" which contains the plants, of which several are considered as identical with those of the Rajmahal hills, for all the beds which I have previously noticed, and which appear to represent the jurassic deposits of Europe from the Bathonian upwards to the Tithonian, compose only the "Lower Jura" of Mr. Wynne's divisions, based on the physical relations of the beds. To answer this question satisfactorily in the present stage of our knowledge is impossible; we must be content to wait the result of further research into the fossils to be found in this interesting province.

THE RAIGUR AND HENGIR (GANGPÚR) COAL-FIELD, by V. BALL, *Geological Survey of India.*

The coal-field thus denominated has hitherto been generally spoken of as the 'Gangpúr field.' The result of my examination having been to show that the greater portion of the area is contained in the district of Raigur and the remainder in the sub-zemindari of Gangpúr known as Hengir (or Hingir)—no portion of the coal-bearing rocks or their associates extending into Gangpúr proper—it seems undesirable to perpetuate a misnomer which is only calculated to mislead.

Whether this area is entirely detached from the Údípúr field or not I am at present unable definitely to affirm. My impression is, that a connection does exist towards the north-

* The Lower Kimmeridgian is only represented by a single species, *Asp. iphicerum*, from N. of Dhosa out of a dark-red fine sandy ferruginous rock.

west, but where I crossed from one to the other there was an interruption of continuity caused by a strip of about four miles of metamorphic rocks. These may possibly only exist as a spur from the southern boundary, which, while they penetrate the area of sedimentaries, do not extend sufficiently far north to cause an absolute separation of the two fields.

Approaching this field from the west, I first struck it about a mile, or rather less, east of the village of Bagchapa on the Kurket in Raigur, and thence traced it to its extreme eastern extension at Kosira on the Baisandar in Hengir. The distance between these points is 34 miles in a direct line. So far as my time admitted, I examined the country to north and south, and at many points ascertained the definite boundaries. At others I was obliged to content myself with conjecture, but from such data as I possess I feel confident that the area occupied by the three groups of sedimentary rocks which occur in this field will be found to extend over at least 400 square miles.

With this introduction I shall, before proceeding to the actual details resulting from my preliminary examination, briefly allude to such previous notices as exist regarding the occurrence of coal and coal-bearing or associated sedimentaries in this area.

Colonel Haughton, 1854.*

Colonel Haughton alludes to the Gangpúr coal formation as possibly connected with that of Sirguja and Palamow, but adds, "on this point I have no reliable data."

Captain Saxton, 1855.†

Captain Saxton communicated to the Asiatic Society in 1855 some particulars regarding coal in the Gangpúr Raja's territory, some 50-60 miles north-west from Sumbulpúr and 25-30 miles from Puddumpúr on the Mahanudi. He writes, "should Calcutta and Bombay be hereafter connected by railway this coal would lie on the way. The bed appears very extensive. A nalá running into the Ebe river which joins the Mahanudi about ten miles above Sumbulpúr passes over, and through, it, and masses of the upper coal which is very light are floated down in the nalá in the rains."

No further precise information regarding the locality is given, though little doubt can exist that the Baisandar is the 'nalá' alluded to.

Dr. Oldham.

In a preliminary notice on the coal and iron of Cuttack by Dr. Oldham, reference is made to this discovery by Captain Saxton. Time did not admit of the Officers of the Geological Survey—at that season engaged in Cuttack—visiting the locality.

Topographical Survey Map.

On the Topographical Survey Map, recently published, the occurrence of coal is indicated in several localities, especially in the Baisandar river.

The formations occurring in this area are Tálchírs, Barákars, and Upper sandstones, &c., (? Mahadevas).

TÁLCHÍRS.

The only place at which I met with rocks belonging to the Tálchír series in this field was near the village of Kosira at the north-east corner of the area; they are very indistinctly seen, and much mixed up with a kind of *arkose* bed, which is precisely similar to one occurring on an undoubted Barákar horizon, and which will be found described further on. In the Baisandar below Kosira they consist of greenish and yellow sandstones with a boulder bed.

* J. A. S., B., 1854.

† Proc. A. S., B., March, 1855.

Mr. Medlicott found Tálchírs all along the southern boundary of this area striking north-west from Sumbulpúr, but I had no time to connect these with my work.

BARÁKARS.

The Damúda rocks occurring in this area probably belong to the Barákar group. For the most part they rest immediately on the gneiss, and are covered and overlapped by the upper sandstones and grits so completely that but for the denuding action of rivers they would now be altogether concealed. This is more particularly the case in the eastern portion of the area where the best coal seams occur. Thus, in the Baisandar and Jhajia rivers the Barákars are merely exposed in the beds, while the upper rocks compose the opposing banks.

It will be more convenient to describe the sections from east to west; I therefore commence with that of the Baisandar river.

In the bed of the Baisandar, the most eastern outcrops of Barákars occur south of Kosira. From this point the northern boundary of the field can be most distinctly traced through the southern *tolah* of Tikripara; the south-eastern boundary is less distinct, but I am inclined to believe that a strip of Barákars, bounded by the gneiss on the east and by the upper sandstones on the west, occurs at least as far south as the village of Balingá.

The section of the Baisandar for about a mile west of Kosira discloses ordinary Barákar sandstones and the arkose bed above alluded to; this consists of granitic and schistose materials not showing any sign of having been subject to weathering. Beyond these rocks there is a succession of rolling seams of carbonaceous shale with occasional bands of coal; these strike with the boundary, but as they are all nearly horizontal, constant repetitions occur in succeeding streams, and I had not time to trace out the section in sufficient detail to enable me to affirm positively how many distinct seams exist. The first promising seam which I measured occurs 250 yards south of the Jhapurnga and Tikripara road crossing. The following is the section:—

Descending: dip 15° to 30° south of east.

		Ft.	In.
	SANDSTONES.		
1.	Blue shales	3	4
2.	*Coal*	4	7
3.	Irregular mass of blue shale	2	6
4.	*Coal*, upper portion shaly	3	10
5.	Parting	0	2
7.	*Coal*, about	5	0
	Several feet below not well seen.		

The coal in this seam at first sight looked very promising, but on analysis it has proved to be of inferior quality, the proportion of ash being 30·6. I very much fear that there is at present no promise of coal of better quality and of workable thickness being found in this neighbourhood. Below is a seam of 80 feet of carbonaceous shale with portions coaly. This could not be measured without excavations being made, for which there was no time. But it gives no promise of containing a workable thickness of coal.

The reaches above this expose the top of a fine seam of carbonaceous shales with coaly bands. The strike being with the stream, a very peculiar terraced appearance is produced. Above its junction with the Jhajia the course of the Baisandar is from north to south, and thus a very distinct section is obtained of one of the largest seams which has been recorded as occurring anywhere.

It is most unfortunately deficient in workable thicknesses of good coal. The following is the section:—

Ascending.

		Ft.	In.
1.	Coarse grit sandstones with interpolated carb. shales ...	0	0
2.	Blue and sandy shale	2	0
3.	Inferior coal with partings of carb. shales, central portion all coal	6	10
	Carried forward ...	8	10

		Ft.	In.
	Brought forward ...	8	10
4.	Sandstone (thinning out to O)	1	8
5.	Blue and black shales with occasional coaly layers of 1 inch and less	5	5
6.	Ditto, more coaly, but useless	2	0
7.	Blue shales	0	7
8.	Papery *coal* and coaly shale	4	1
9.	Blue shale concretionary	1	10
10.	Carb. shale passing into coaly shale	5	6
11.	Blue concretionary shale	5	8
12.	Carb. shale with flaky *coal*	4	10
13.	Blue concretionary shale	1	8
14.	Carb. shales	0	8
15.	Flaky *coal*	2	0
16.	Blue concretionary shales	0	8
17.	Carb. shales, portions coaly	2	9
	Same decomposed	3	6
18.	Blue concretionary shales—Dip south south-east 4° ...	6	0
19.	Carb. shale and flaky *coal*	1	10
20.	Blue concretionary shales	1	9
21.	Flaky carb. and coaly shale with charcoal markings, coaly portion containing much red oxide of iron...	1	6
22.	Blue concretionary shale	2	10
23.	Stony *coal* very impure	1	2
24.	Ditto, portions flaky...	1	3
25.	Flaky carb. shale	2	0
26.	Blue concretionary shale	4	7
27.	*Coal* with red oxide of iron	1	10
28.	Carb. shale	0	3
29.	Flaky coaly shale	1	0
30.	Blue shales	1	2
31.	Flaky carb. shales—portions coaly—Dip 4° south south-east ...	7	0
32.	Carb. shales	1	3
33.	Same as 31	2	6
34.	Blue concretionary shale. Dip south 6° (corner of bend) ...	1	11
35.	Impure *coal* much mixed with red oxide of iron and passing into flaky coal and carb. shales	3	10
36.	Concretionary shale	2	7
37.	Flaky *coal* with iron	0	10
38.	Carbonaceous shale	1	2
39.	Concretionary blue shale	1	3
40.	Carb. shale and coaly shale	1	9
41.	Blue shale	1	4
42.	Carbonaceous shale and stony *coal*	1	10
43.	Flaky *coal* with carb. shale	3	6
44.	Concretionary blue shale passing into pinkish carb. shale ...	3	8
45.	Flaky *coal* with carb. shale	1	3
46.	Blue concretionary shale	3	8
47.	*Coal* permeated with iron	1	2
48.	Flaky *coal*, about	2	0
49.	Concretionary blue shale	3	0
50.	Carbonaceous shale and flaky *coal* ... ... 1' 4" to	2	0
51.	Massive sandstones irregularly interpolated and thinning out to south	10	10
52.	Carbonaceous shales	0	8
53.	Coaly shale containing much iron and alternating with carb. shales	2	0
54.	Blue and black concretionary shale	9	0
55.	Same as 5	0	9
56.	Concretionary blue shale	7	0
57.	Concretionary blue and black shales with concretionary layers. Dip 4° south	12	0
	This is on southern bank of Baisandar.		
	TOTAL ...	168	7

This seam is also seen in the streams west of the village of Sardega, but not so clearly as in the Baisandar.

Below No. 1 of the above seam there are some Barákar grits, and underneath them some arkose beds, which plaster over granitic gneiss, showing a most distinctly natural boundary.

There are no traces of coal or other sedimentary rocks brought down from further north by the Baisandar. This, though not a *proof* that none such exist, may be taken as collateral evidence in favor of the view —also supported by the physical characters as represented on the map—that uncovered gneiss continues up to the plateau and is connected with the main gneiss of Eastern Udípúr, &c.

In the bed of the Jhajia river westwards, the large seam becomes much broken up by interpolations of sandstones and shales, and with the dying out of the more coaly bands the change is so complete that it is impossible to recognise it or trace any portion of it through successive reaches. Between Ratansarai and Ghogarpali there are several seams or repetitions of a seam, but none contain coal of useful quality and thickness. As above mentioned, the upper sandstones appear on either bank, and in one place occupy the bed of the stream itself. South of Ghogarpali there is a seam containing about 30 feet of shale to one of coal. Above the village it is seen again, a portion having been burnt: in the unburnt part there is a band of 8 inches of very good coal and several thinner layers. About 25 feet in all of this seam is exposed at this second locality.

Between this and Bograkachar there are frequent outcrops of carbonaceous shale with coaly layers belonging to several distinct seams. Close to Bograkachar there is a seam of similar character with a slight indication of a dip to east south-east. The contained coal is in very thin layers. How far these rocks may extend northwards up the bed of the river I had not time to ascertain, but from the pebbles I think it probable that the gneiss cannot be very far distant.

This little area of carbonaceous rocks which occupies the beds of the Baisandar and Jhajia rivers may be best understood by regarding it as a vast seam of some 500 feet of coaly and carbonaceous shale with irregular partings and interpolations of sandstones. Occasional thin bands of good coal occur, but they are rare, and the prevailing components of the seam are blue and black carbonaceous shales.

The prominence and abundance of the outcrops are such that no one could possibly avoid noticing the coaly looking beds which are particularly well exposed in the vicinity of the road crossing at Tikripara.

As to the extension of these seams southwards underneath the upper sandstones nothing certain is at present known, and should it be found that the latter rest immediately on the Tálchírs of the south boundary, then it will be impossible to solve this question without having recourse to borings.

The centre part of this field is traversed by two principal streams, the Koldiga and the Kelo, with a number of smaller tributaries. The high ground between these is probably for the most part occupied by outlying patches of the upper sandstones, while in the river beds Barákar rocks are exposed.

Kelo Section.—In the river section between Jhargaon and Hokra there are several outcrops of seams consisting of carbonaceous shale. Only one, that near Tiptipa, contains coal, but even there it is in too small quantity to be of any use. At Hokra there is a 10 foot seam of concretionary shale, no coal—dip 4° to 35° east of south.

Beyond the Gari Ghát there is a 2 foot seam of concretionary shale and coal—dip 7° south.

In the Bendia (near the mouth), which joins the Kelo at Gari, there is a considerable seam.

Ascending—Dip irregular, south-west 5°.

	Ft.	In.
1. Carb. shales, bedding irregular, with some slight coaly layers towards base	4—5	0
2. *Coal*, portions flaky, but for the most part burnable, much weathered	4	10
3. Parting, ferruginous sandstones	0	6
4. Flaky *coal* with carb. shale excessively weathered and decomposed	6	0
	15 4—16	4

I think it possible that some good coal might be extracted from this seam. In its present decomposed condition even, it is easy to see from the manner of weathering that good or fair coal exists. The thicknesses given above do not hold for all parts of the seam. In this same stream (Bendia) higher up a rolling seam of carbonaceous shale with a few inches of coal continues on both sides for about half a mile.

Between this and the village of Kornkel there are three seams consisting of blue shales, the most southern of which contains some layers of good coal 6 inches thick.

Returning to the Kelo section. At the top of the next reach beyond the mouth of the Bendia there is a seam containing 12—15 feet of blue and black shales with coaly layers—dip 4° to 30°, south of west.

In the next mile and a half four or five seams are met with; they are apparently repetitions of those above alluded to in the Bendia; none of them contain any useful quantity of coal.

At Milupara there is a change in the dip to more or less north of west, and two or three seams are exposed with intervals covered. Sandstones are the only rocks seen up to Khara, but near the village there are some greenish fine sandstones which I at first thought might be Tálchírs, but they appear to overlie the carbonaceous shale. Near Khara there were still fragments of coal in the stream, which showed that the northern limit of the Barákars had not been reached. There were also, however, a quantity of gneiss fragments which had not the appearance of having travelled any great distance. The hills formed of the upper sandstones impinge close on the banks of the river in this neighbourhood.

Koldiga Section.—In the Koldiga below Mal[illegible]i there are rolling carbonaceous shales with ironstones and flaggy beds, but I did not see any coal. The whole aspect of these rocks reminded me more of the "*carbonaceous shale and ironstone group*" than of any other rocks of the Damúda series which I have elsewhere met with. I am not, however, prepared to say at present whether they are susceptible of separation from the Barákar group.

Between the Samkera and Parega and Samkera and Gasbahari road ghâts the flags accompanying the carbonaceous shales present a very peculiar appearance, being of green buff and grey colors, sometimes resembling Tálchírs, but always closely connected with the carbonaceous shales.

East of this the section consists principally of carbonaceous shales up to Dumartoli, where the stream falls from the higher ground occupied by the upper sandstones.

Much remains in this area to be done in the detailed separation of the Barákars from these upper rocks. Except where there are marked physical features, owing to the slightness of the contrast in lithological characters, it is extremely difficult to draw a satisfactory boundary.

West from the Kelo the coal-bearing rocks are found for a distance of 13 miles.

In the Pájú river there are some fragments of coal brought from some seam or seams north of the high road, but none are exposed in its immediate vicinity.

In the Dighi stream at Deogurh there is a seam of blue and black carbonaceous shales with 5 inches of coal at the top. No better seam is exposed in the river for a mile to the south.

In the Hurinara stream there are sandstones and some traces of coaly and carbonaceous shales. Between the valleys of Simra and Charatanga there are some ferruginous sandstones, possibly Barákars. Between Charatanga and the Kurkot river there are Barákar sandstones, and the same are better seen in the bed of the river itself. The section examined in both directions north and south for about half a mile showed no signs of coal *in situ*, but fragments occur in the bed of the stream.

The boundary of these rocks must cross the Kurket about midway between the villages of Rábo and Bágchapa.*

Bágchapa itself is on gneiss, and about a mile to the south the boundary of the Vindhyans is marked by a low range of hills.

UPPER SANDSTONES.

The manner in which, especially in the eastern portion of this field, the coal-bearing rocks have been covered by the upper sandstones has been already alluded to. The principal area of these rocks exists south of the strip of Barákars which are exposed at the drainage level by the rivers and streams. How far it extends southwards is not known, and the important economic question as to the extension of the coal measures underneath has still to be determined. If it be found that the Barákars crop out from beneath them and rest on the Sumbulpúr Tálchírs described by Mr. Medlicott, then the question will be solved, but if, as is possible, and in some degree probable, the upper sandstones lap over on to the Tálchírs without any appearance of Barákars intervening, then the extension of the latter can only be ascertained by borings.

North of the Barákar sections the upper sandstones form large hills, sometimes resting on the former and sometimes resting immediately on the gneiss, as is particularly well seen in the valley north of Jhanjgir. The lithological characters of these rocks are very much the same as they were in the northern fields—highly ferruginous sandstones and grits, and red brown and ochreous clays sometimes with fragments of plants. The bedding is for the most part horizontal, and apparently does not partake of the rolling which characterises the underlying Barákars.

DESCRIPTION OF THE SANDSTONES IN THE NEIGHBOURHOOD OF THE FIRST BARRIER ON THE GODÁVARÍ, AND IN THE COUNTRY BETWEEN THE GODÁVARÍ AND ELLORE, by WILLIAM T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey.*

A brief notice of the great sandstone tract in the valley of the Godávarí and its tributaries has already been given in the Records of the Geological Survey of India for 1871, pages 49—52. The following pages furnish a somewhat more detailed account of the south-eastern portion of this area, extending from the junction of the Tál with the Godávarí to the alluvium of Yelaur (Ellore) and Rájámahendrí.

The only portion of the country which has been closely examined is the area occupied by the Damúda rocks, which are seen in the Godávarí just below the junction of the Tál, and again about 30 miles lower down the river near the village of Deorpalí and Ganara on the left bank, and of Amravåram, Damarcherla, and Mádavåram on the right. The remainder

* As I had no map whatever of this country, I did not attempt any detailed examination.

of the sandstone tract, consisting principally of Kámthí beds, has been more cursorily surveyed. Tálchírs occur in several small patches, mostly isolated, in the immediate neighbourhood of the river.

The description commences at the northern extremity of the area, at the confluence of the Tál and Godávarí. The various rocks seen on the banks of the latter river between the Tál and Bhadráchalam are noticed in succession, then the sandstones around Ganara and Deorpalí north of the Godávarí; and the remainder of the paper is composed of notes on the sandstone tract extending from Mádavåram and Palúnchá on the north to the coast alluvium on the south, commencing at the north-east corner near Mádavåram.

The country has hitherto attracted but little attention from Indian Geologists: a portion of it is briefly described in Dr. Voysey's Second Report on the geology of Hydrabad* and in the extracts from his private journals ;† and the sandstones on the river banks are noticed by Mr. Wall in his "Report on a reputed coal formation at Kota."‡ But none of these papers do much more than to mention the existence of sandstone or other rocks in particular spots.

It may be as well briefly to mention the features of the Godávarí valley above the mouth of the Tál. From Sironchá the river runs through sandstones as far as the commencement of the second barrier just above the confluence of the Indraotí river with the Godávarí. Here it enters metamorphics, the sandstones (Kámthí, &c.,) occupying the country to the south-west. At the bottom of the barrier, after traversing a band of Vindhyan quartzites, the river enters the plant-bearing sandstones, and they are the only rocks seen upon its banks from this point to the mouth of the Tál, but at a short distance inland from the left bank a high range of Vindhyan quartzite runs parallel with the river, and terminates, a few miles before reaching the Tál, not far from the large village of Charla, whilst the quartzites and their associates extend as far as the Tál, and re-appear south of it. On the right bank of the river the sandstones stretch for a considerable distance, much farther than on the left.

All the country between Charla and the Godávarí appears to be alluvial; no rock is seen in the river bank for a long distance above the mouth of the Tál.

Rocks near Charla.

On the road from Charla to Tiagra (Tengra) Tálchírs are seen about a mile from the Tál. Some more are met with in the jungle to the eastward; but between the road and the Godávarí none were detected. At Charla itself, nothing could be seen on the surface, and the hills to the eastward are of Vindhyan sandstone, but blocks of unmistakeable Kámthís have been dug out from the north side of the village to repair the tank. There can, I think, be but little doubt that these are in place, and, if so, both Damúdas and Tálchírs, which appear to the southward, must here be overlapped.

Rocks near mouth of Tál just above Lingálá.

In the branch of the Godávarí east of the island (char or lanka) above the mouth of the Tál one solitary block of coarse conglomerate is seen. Precisely similar rocks come in, dipping at about 17° to the west at the spot where the Tál joins the Godávarí. At this place fragments of coal have been picked up, but despite much search, borings through the sand, &c., their source had not been discovered until after I had left the country.§ Three hundred or 400 yards above its mouth, Tálchírs appear in the Tál, dipping

* J. A. S., B., 1833, Vol. II, p. 392.

† Id. 1850, Vol. XIX, pp. 287-288 and 296-302.

‡ Mad. Jour. Lit. and Sci., 1857, Vol. XVIII, p. 256.

§ Since I left the Godávarí, Mr. Vanstavern has cut into a small seam of coal under the rocks on the north side of the Tál at its mouth. It is about a foot thick and very shaly. This is doubtless the source of the coal found at this spot.

at a high angle to the westward, and the same rocks recur at intervals for about three miles; then limestone belonging to the Vindhyans makes its appearance. This limestone has been employed in the anicut and locks at the first barrier.

Above Tiagra the Tálchírs seem not to extend far east of the bed of the Tál, metamorphics appearing near the stream on the right bank. On the left bank a hill of Vindhyan sandstone appears just above Keshúpúr. The range of hills east of Tiagra, extending to Halverú, are of Vindhyan quartzite, east of which metamorphics occur. To the west of them Tálchírs are seen near Tiagra, but to the southward all is alluvium between the road to Dúmagúdem and the river.

Rocks on banks of Godávarí near Lingálá.

Along the (left) banks of the Godávarí below the mouth of the Tál, reefs of typical Damúda sandstone, more or less conglomeratic, run parallel with the bank to some distance south of Lingálá. The dip is west, and west by south,—at Lingálá W. 30°—40° S.,—with an inclination of 17° to 20°. These beds abound in Vindhyan pebbles and detritus, by which they are coloured quite red in some places. Small seams of coal have been found amongst them by Mr. Vanstavern in two or three places, but none exceeded 2 feet in thickness, and they can be traced a short distance only. Reefs of similar rocks occur in the river at a distance from shore, and beneath one of them a seam 5 feet thick was found by Mr. Vanstavern.

At Omadháram, below Lingálá, the river bank falls back to the eastward, and the strike of the rocks turns to the south, and then south-west, crossing the river. Beneath the lowest reef of Damúda conglomerate seen is some fine sandstone, probably belonging to the Tálchírs. Below this no rocks are seen on the left bank of the river for more than three miles. About two and a half miles above Parnasálá metamorphics appear, and continue as far as Dúmagúdem.

Rocks south-west of the Godávarí near Managúr.

Above the spot, at a village called Tarkala Singaram (Ryechelgoodium on one map) where the Damúdas appear on the right bank opposite Lingálá, striking across the river, no rocks are seen in the river bank as far as Biaram, a distance of eight or nine miles, and the country near the river bank consists of alluvium. Further inland rock crops out here and there, but much of the surface is covered with sand or sandy clay. On the road from Managúr to Mangampet coarse felspathic sandstone is seen in two or three places. There is a hill of conglomerate dipping westward, south-west of the village of Románjá, and coarse sandstone and conglomerate is seen near Pyáran Tank. The hills west of Managúr consist of similar beds, white and brown in colour. The sandstone has the same loose pseudo-vesicular texture which is seen in some of the Kámthí beds, and in one spot hardened clay is intermixed with the rock as at Sironchá. The dip is low to the west or west by north.

Rocks near Singaram.

Rock is exposed here and there throughout the thick jungle with which all the country is covered, except in the immediate neighbourhood of the river bank. Some small pits were made and borings put down near Singaram, and sandy shale and clays, white, pale buff, pink and brown, were met with, some of those cut into in the pits containing *Glossopteris*. The beds seen at Singaram must be a continuation of the Damúdas seen at Lingálá, but it is impossible to say how much, if any, of the coarse sandstones and conglomerates seen west of Managúr should be ascribed to this group. Judging from the other rocks found to the south-east, a large proportion of these beds are probably Kámthí, and there is every appearance of the Damúdas being overlapped by the Kámthís near Managúr, as they are in all probability at Charla.

Rocks on right bank of Godávarí below Singaram.

The beds seen in the river bank at Singaram are brown and white sandstones, evidently Damúdas, and the prolongation of the rocks seen at Lingálá. Their dip varies, being usually W. 10° to 20° N., and about 20°, but it ranges from 10° to 30°, and is difficult to make out exactly. Down the river, Tálchírs come in about half a mile or rather less below Singaram and 200 yards west of the village of Yegúradigúdem, and dip north-west about 12°. They are thence seen in the river bank at intervals for about three and a half miles, as far as a little village called Raigúdem. Here the last outcrop of Tálchírs occurs at a small jutting point; metamorphics appear about 200 yards further down the river, near the houses of the village. A hill not more than 100 yards from the river bank is of Vindhyan quartzite, but in the river itself only metamorphics are met with. The dip of the Tálchírs is somewhat irregular, but chiefly to the north-west, and a considerable area must be exposed.

Country west of Godávarí near Dúmagúdem.

The country west of the river from this to Bhadráchalam was only very cursorily examined. The great ridge of Ratangota running north-east to south-west is of Vindhyan quartzite; it is isolated, being bordered by metamorphics on the south-east, and partly on the north also; while to the west and south-west Tálchírs occur, and a belt of them extend from its southern extremity to the Godávarí at Dúmagúdem, the village of Mitagúdem resting upon these beds. Vindhyans re-appear in the hills south and south-east of Mitagúdem; they form the hill about a mile west of the Godávarí opposite Dúmagúdem, and extend south as far as Gondigúdem, and thence for an unknown distance to the westward. They are much hardened, and the softer beds are rather schistose. The southern boundary of the plant-bearing series runs from Ratangota hill westwards through Búga, where there is a hot-spring; all Damúdas and Tálchírs disappearing and massive Kámthís abutting against the Vindhyans. From near Búga the boundary runs south-west through a very wild jungle, metamorphics replace the Vindhyans, the latter not being found to the southward so far as the rocks were examined, whilst the area of the plant-bearing sandstones extends for an unknown distance to the west towards Paikhal.

Rocks in Godávarí near Dúmagúdem.

The anicut of the first barrier opposite Dúmagúdem is on metamorphics, but just below Tálchírs come in, apparently continuous with the larger area to the westward. They occupy the river bed for rather more than a mile, and are seen on both banks, but do not appear to extend to the eastward. They are quite characteristic, mudstones and fine sandstones; the dip is variable. Just below Amágarpali some coarse gritty hard sandstone is exposed, dipping north-west; it is unusually coarse for Tálchírs, being even conglomeratic.

Inaccuracy of map.

The map west of the river is very inaccurate, and the two banks by no means coincide. Just below the anicut, the right bank is marked too far south or down the river by 200 yards, whilst a mile farther down points on the right bank are a quarter of a mile farther north than those which are really opposite to them on the left bank.

Tálchírs south of Dúmagúdem.

A small exposure of Tálchírs is seen on the right bank of the river at Sinterál, two miles or rather more below Dúmagúdem; another on the opposite bank (perhaps part of the same) just below. The latter extends for about a mile east of the river. Tálchírs again occur on the left bank just above Dáutheram point, which is of granitoid metamorphics, and a mile and a half below they are seen for a mile along the left bank, not extending across to the right. They, however, stretch inland, to the eastward for about six miles.

The lowest beds seen on the river bank west of Narsápúr are compact fine grained sandstone dipping north-east and resting with pseudo conformity, as not unfrequently happens, on the metamorphics. South of Narsápúr, and a little east of the river bank, close to a small nalá, this fine sandstone has been quarried to some extent for the navigation works at Dúmagúdem. It cuts well, but has been found to have a great tendency to split and crumble after exposure.

East of Narsápúr the ordinary shales or mudstones prevail. Boulders, some of them of great size, abound on the road from Narsápúr to Bandalgúdem. One must have been nearly 10 feet in diameter. The larger blocks are metamorphic, but smaller pieces are of Vindhyan sandstone and limestone.

Metamorphics near Bhadráchalam.

From Tárbáká near Narsápúr to Raigúdem, on the right bank of the Godávarí, close to the mouth of the Pámálerú, four miles below Bhadráchalam, only metamorphic rocks are seen in the Godávarí. In Malcolmson's Map* Deccan overlying trap is represented as occupying a considerable area on both sides of the river close to Bhadráchalam. I have not been able to trace the source of Malcolmson's information, but it must have been founded on the large quantity of hornblendic gneiss occurring at Bhadráchalam and in the neighbourhood. Some of this is so compact as to become mineralogically a greenstone.

Trap on Malcolmson's Map.

Banks of Godávarí below Bhadráchalam.

The north or left bank of the Godávarí is composed of metamorphic rocks until close to the village of Deorpalí, whilst the south or right bank consists of sandstone from Raigúdem, the boundary between the two, which appears to be a fault, running along the channel of the river. The hot spring at Gundala, temperature 140°, is concealed beneath the sand of the river, and a small well is annually made in the sand in order to reach it. This is done at a feast in the month of April. The position of the spring is apparently a little north of the boundary between the metamorphics and the sandstone, but as very few rocks are seen, the exact position of this boundary is uncertain.

Hot spring of Gundala.

Sandstones below Deorpalí.

From Deorpalí sandstones occur, wherever any rocks are exposed, on both banks of the river, with one exception, as far as Nándigúr on the left bank, and a little below Mádavāram on the right. The exception is on the latter for about a mile and a half above the village of Polāram, where metamorphics appear. Below Mádavāram no sandstones are known to occur.

The sandstones around Raigúdem, Deorpalí, Mádavāram, &c., are part of the great area extending southwards to the neighbourhood of Ellore and Rájámahendrí, which has been briefly described in the Records of the Geological Survey for 1871, p. 49. A full detail of the boring operations is given in the same volume of the Records, p p. 59-66.

Arrangement of notes on the sandstone area.

In proceeding to describe the geological features of the sandstone area extending from Raigúdem, Deorpalí, and Mádavāram on the north to the alluvium of Ellore, it will be most convenient first to give such notes as have been made on the small tract north of the river near Deorpalí, next those on the isolated area to the south around Mádavāram, and finally a brief account of the large extent of sandstone extending to the southward from Raigúdem and Palúncha.

* Geol. Trans., Ser. 2, Vol. V, pl. XLVII.

Sandstones north of Godávarí near Deorpalí.

In the small sandstone area extending along the north or left bank of Godávarí from Deorpalí to Nándigúr but little rock is exposed, except in the hills near the first named village, the greater part of the ground being thickly covered with river alluvium. The sandstones extend inland from one to two miles from the river bank, and consist principally of Damúdas, Tálchírs being seen at or outside of the northern boundary in two places, whilst the rocks forming the Deorpalí hills are probably of Kámthí age. It is possible that this tract and the corresponding one south of the river around Mádavåram are faulted in places, as some of the few dips seen are confusing and anomalous.

Sandstone tract near Deorpalí.

The exact position of the eastern boundary is, in great measure, undetermined. The first rocks exposed are in the Nandi Vágú* near Nándigúr. In this, for about half a mile from the Godávarí, fine yellow felspathic sandstone is seen in places, dipping at a considerable angle to north-west by west, that is, in the direction of the boundary. Metamorphics occur to the eastward, but not in the immediate neighbourhood of the stream. The last sandstone seen to the northward in the stream bed has low but irregular dip. Above this no rock is seen for more than a mile, but sandstones probably occur, because rolled pebbles of quartz, &c., are abundant west of the stream and south of the village of Nálagúnta. Metamorphics make their appearance in the Nandi stream nearly due east of this village.

No sandstone whatever is seen in place between the Nandi stream and the Ganár, but metamorphic rocks crop out to the north. Two boreholes put down north of the village of Ganara entered quicksands at depths of 34 and 22 feet respectively, and it was found impracticable, after sinking in the first instance through 18 feet, and in the second through 24 feet of loose sand and water, to penetrate to the rock. In the Ganár Vágú Damúdas are seen in two or three places about half to three quarters of a mile from the mouth, and in a boring at one of these coal was discovered (see Records, 1871, pp. 61-62). Above this metamorphics appear, but still further north Tálchírs are met with, and extend north for about a mile towards the villages of Malipúr and Kishtáram. They are almost, if not entirely, separated from the Damúdas, metamorphics intervening not only in the stream, but to the east of it, while to the west the surface is much covered by alluvium.

West of the Ganár stream sandstone is exposed in several places near the village of Tátpali and south of Egerpeta, but the dip is obscure. Apparently it is to the south, and the borings put down south of Tátpali appear to indicate that it is very slight. But at one spot, at a tank almost due south of Egerpeta and north-west of Golagúdem, sandstone is seen dipping to the north-east at 60,° proving the existence either of faulting or of great local disturbance. From this place little, if anything, is seen to the westward as far as Gogúleáká. In a field close to Egerpeta some Tálchír shales were found, but none could be detected thence to the westward till about half a mile east of Ghútipár, where they are exposed along the boundary for a short distance, and are well seen in a small nalá, all in thick jungle.

The hills near Deorpalí consist entirely of grit or conglomerate, and no shale is seen in the section exposed in the river. It appears most probable that the rocks belong to the Kámthí group. Whether a fault, in continuation of the boundary south of Mádavåram, runs up the river, separating these rocks from those of Amraváram, is doubtful. Even if such be the case, it may be of older date than the Kámthís, which here, as near Lingálá, appear to be proved by their distribution to be quite unconformable to the Damúdas.

* Vágú, Telinga for stream, equivalent to Nadi in Hindustani.

Sandstone tract near Mádavāram.

The tract of sandstone on the right bank of the river opposite to that just described extends from near Mádavāram to Polāram, or rather more than four miles from east to west. Where broadest it is between two and three miles from north to south. The southern boundary is nearly straight, and although there is not, except in the south-east corner, much appearance of disturbance along it, it is difficult to believe that it is natural. The dip throughout is to the westward, and usually rather high, being seldom less than 10°, frequently 15°, 20°, or even 30°. Tálchírs occur in the extreme south-east corner; all the remaining area appears to be occupied by Damúdas.

The Tálchírs are only seen in a stream which runs into the Godávarí near Ráigomá; they are the usual fine silty shales and sandstones, and are vertical, or dip at high angles to the west and north-west. They were not seen between the two hills just north of this spot, the one of metamorphics, the other of Damúda grit and conglomerate.

The whole eastern boundary of the rocks north of these two hills is concealed by alluvium in the river, which here runs north and south; metamorphics are seen along the left bank. To the east of the alluvium is a low rise formed of conglomerate, extending north to the river east of Mádavāram and terminating on the south in the high hill just referred to, which lies west of the village of Kondapali. This hill has precipitous sides to the east and south, exposing a section of the conglomerates composing it.

In the small stream which runs into the Godávarí near Injáram, north of Kondapali, much conglomerate is seen, but no continuous section is exposed for any distance. Rocks are traced at intervals along the southern boundary of the field, and are usually conglomeratic. The hills near Polāram and a smaller rise south-east of it are of the same kind of rock. This of course is in favour of the southern boundary being natural, but it should be remembered that the conglomerates being harder, are more likely to be exposed than the softer rocks which may intervene between them. There is much lime along the southern boundary near the villages of Palchalkar and Gangáram, some compact limestone occurring north of the last named village, but it is apparently a superficial accumulation.

Throughout this sandstone tract, as a general rule, very little rock is seen; usually when any appears above the surface, as west of the tank south of Shirúveli, it is grit or conglomerate. But a tolerable, though by no means continuous, section is exposed in the bank of the Godávarí. Here also the eastern boundary is not seen, metamorphics are met with about half way across the river bed (here about a mile broad) opposite the village of Murmur, and at the salient angle of the river bank below Mádavāram there is horizontal conglomerate and grit, being the same beds as those forming the rise which bounds the sandstone tract on the east. The conglomeratic character appears to diminish rapidly to the westward, in which direction the beds for a short distance dip east, exposing about 100 feet of rocks, sandstone grit, and some argillaceous beds. The dip then changes to the westward just at the mouth of a small nalá, and grey or pale brown sandstone with occasional bands of grit or shale, all of typical Damúda characters, dip at a high and rapidly increasing angle to the westward. At the anticlinal opposite the mouth of the little nalá, a borehole was made to a depth of 193 feet 6 inches in order to prove rocks lower than any exposed on the section. It went through alternations of brown and white sandstones, with thick beds of dark shale containing two or three small and useless seams of coal, none of them exceeding 8 inches in thickness (see Records, 1871, p. 61).

At Mádavāram there is some crushing and, possibly, faulting, the sandstone being cut up by calcareous veins. A high dip, varying from 20° to 40°, continues along the river bank as far as Shirúveli, the beds being coarse or fine sandstones of varying hardness with occasional shales. Near Shirúveli the dip becomes lower. In some clays just east of the village *Glossopteris*, *Pecopteris*, *Vertebraria*, and *Calamites* occur.

Thence to Damarcherla the dip is moderate, about 5° to 10°, and the rocks fairly seen on the whole. They are much the same as to the eastward, fine felspathic sandstone and fine clays predominating, with occasional hard massive bands of fine brown sandstone. At Damarcherla there is a little conglomerate and some hard ferruginous bands like those in the Kámthís.

About half a mile, or rather less, west of Damarcherla, the beds roll up sharply, and there may be a fault here. They soon roll over again and consist of coarse felspathic sandstones, generally pink coloured or ferruginous, and conglomerates, but associated with hard compact grey felspathic sandstones. These rocks continue to beyond Poláram, metamorphics appearing at the mouth of the stream west of the village.

Magnetic iron ore near Poláram.

Iron manufacture.

A small rising ground in the metamorphics south of Poláram contains large quantities of magnetic iron ore in laminæ with quartz. The ore has evidently been largely dug from this spot for small diggings are scattered over the ground. The iron ore shows very distinct polarity in its action on the needle. In a small village near this I found women making iron in a little furnace barely 2 feet high—a miniature of the Tálchír furnace—worked by small foot bellows about 1 foot in diameter. The furnace inside is only 6 inches in diameter at the base, 3 inches at the top. It is said by the people that two pieces of iron, each weighing 1½ seer and valued at 4 annas, are made in a day.*

Sandstones near Púndigúl and Amravá-ram.

Sandstone again comes in on the right bank of the river close to the abandoned village site of Púndigúl. The actual junction of the two series is again concealed, but there can be little doubt of the boundary being natural. It runs to the southward into dense jungle, where its position is difficult to ascertain correctly on so imperfect a map; the rocks being very poorly seen.

Sandstones near Amravāram.

In the right bank of the Godávarí, from just above the base at Púndigúl to the village of Amraváram, a good section is exposed in which very few breaks occur. The general dip is west, varying in amount from about 7° to 12°. Towards the base yellowish-brown sandstone prevails, coarse and felspathic. Above this, to the north of the hill, there is much conglomerate, and thence to Amraváram sandstone again. No clay or shale is seen, much less coal, but some coarse impure ironstone occurs.

About the middle of the village† the section ends, and only scattered outcrops, concealed beneath the river except in the driest season, occur in the bank of the river above. Just above the mouth of the stream, which enters the river above the village, fragments of coal occur on the river's bank just below a conspicuous clump of green bushes; some sandstone occurs in the bushes, and a boring might be put down through it. Above this, again, but one small outcrop of rock is seen, nearly in front of Thondipálí, as far as Gúmpanápali just below Rágúdem. Even near Mondipák (nearly opposite Gagúbáká) only a few blocks of coarse sandstone are exposed. Near the river bank the country is an alluvial flat, and farther inland a sandy rise covered with thick jungle, amongst which a few scattered blocks of coarse sandstone and conglomerate may occasionally be seen.

* The people were of Lohar caste, *i. e.*, low caste Hindus. The Kois, who are Kolarians (though called Gonds by the Mussulmans of the country), are said to make iron with foot bellows in a hole in the ground without any furnace at all.

† This is placed too far east on the map, which is very inaccurate about here.

The nalá which runs into the Godávarí, east of Amravâram, exposes no rock for some distance from its mouth, and no good section is anywhere seen in it. Soft felspathic sandstones and, towards the base, conglomerates are met with in it here and there. Even less rock is seen in the large Machimangú nalá which runs past Kometlagúdem. Sandstone only appears in this in the form of a few blocks, exposed just below the junction of the two principal streams which unite to form it. The more westwardly of the two joining streams, however, only traverses metamorphics for a very short distance: above this Tálchírs are exposed, although there are none in the main stream a few hundred yards distant, where the metamorphics and Damúdas are seen within a few yards of each other. After about one quarter of a mile of Tálchírs, Damúdas or Kámthís (they are undistinguishable here) again come in dipping west south-west. There is a considerable quantity of coarse felspathic sandstone of various colours, mostly brown, or irregularly streaked, and hard ferruginous bands occur at intervals; occasionally clay is found in the sandstone. Conglomerate is not prevalent, but it is met here and there.

There is absolutely nothing about these beds by which they can be distinguished from Damúdas, but there can be but little doubt that the greater portion, if not all, belong to the Kámthís. From the general dip they must have overlapped the Amravâram beds. They appear softer than the rocks seen in the river's bank near Amravâram and Mádavâram, but this is not an important distinction.

The hills near Kometlagúdem are of open textured felspathic sandstone, usually white or pale brown in colour, with hard ferruginous bands. The sandstones on the hills in this neighbourhood have generally this somewhat open texture, which is not usually seen in ravine sections, and may be due to the washing out of the decomposed felspar from between the grains of quartz. The character of the sandstone is that of the Kámthí beds, but no typical Kámthí rocks occur, neither vitreous sandstone, nor the red and yellow compact shale, nor the fine micaceous variegated sandstone.

From these hills, others formed of similar sandstone stretch away to the southward, bordered to the east in the valley of the Machimangú stream by metamorphics, no Tálchírs intervening.

(To be continued).

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" " The Genera Vermium of Linnæus exemplified by several of the rarest and most elegant subjects in the orders of the Testacea, Lithophyta, and Zoophyta Animalia, (1788,) 4to., London.

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BRANDT, J. F.—Prodromus Descriptionis Animalium ab H. Mertensio in Orbis terrarum circumnavigatione observatorum, Fasc. I., (1835,) 4to., Petropoli.

BREYNIUS, J. P.—Dissertatio Physica de Polythalamiis, (1732,) 4to., Gedani.

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CAILLIAUD, F.—Catalogue des Radiaires, des Annélides, des Cirrhipedes, et des Mollusques, Marins, Terrestres, et Fluviatiles recueilles dans le Département de la Loire-Inférieure, (1865,) 8vo., Nantes.

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THE ACADEMY.

PERIODICALS.

American Journal of Conchology, Vol. VI., pts. 3-4—(1870-71,) 8vo., Philadelphia.

American Journal of Science and Arts, 3rd Series, Vol. I., Nos. 5-7,—(1871,) 8vo, New Haven.

Annales des Mines, 6th Ser., Vol. XVII., Liv. 1-3—(1870,) 8vo., Paris.

L'ADMINISTR. DES MINES.

Annals and Magazine of Natural History, 4th Series, Vol. VII., Nos. 42-44—(1871,) 8vo., London.

BLOCHMANN, H.—Bibliotheca Indica, New Series, No. 236. The Aín-í-Akbari, Fasc. XIII. —(1871,) 4to. Calcutta.

GOVERNMENT OF INDIA.

Canadian Journal of Science, Literature, and History, New Series, Vol. XIII., No. 1, May, (1871,) 8vo., Toronto.

COSTA, O. G.—Fauna del Regno di Napoli, Fasc. 1—116—(1832-1870,) 4to., Napoli.

" " Paléontologia del Regno di Napoli, Parts II., III., with Appendices—(1854-1863), 4to., Napoli.

First Biennial Report of the Progress of the Geological Survey of Michigan—(1861,) 8vo., Lansing.

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Geological Magazine, Vol. VIII, Nos. 6-8—(1871,) 8vo., London.

Indian Economist, with Agricultural Gazette and Statistical Reporter, Vol. II, No. 12, and Vol. III, No. 1—(1871,) 4to., Calcutta.

GOVERNMENT OF INDIA.

Journal de Conchyliologie, 3rd Ser., Vol. X., No. 4—(1870,) 8vo., Paris.

LEONHARD, G., UND GEINITZ, H. B.—Neues Jahrbuch für Mineralogie, Geologie, und Paléontologie, Jahrgang, 1870, Heft 8, and Jahrgang, 1871, Heft 3-4—(1870-1871,) 8vo., Stuttgart.

Paléontographica, Band XIX, Lief. 5, with title page and Index of Vol. XVII, 4to., Cassel.

PETERMANN, DR. A.—Geographische Mittheilungen, Band XVII, Nos. 5-7—(1871,) 4to., Gotha.

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The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 4th Series, Vol. XLI, Nos. 275-278, (1871,) 8vo., London.

The Quarterly Journal of Science, Nos. 29-31, (1871,) 8vo., London.

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" Records of the Geological Survey of India, Vol. IV., Part 3, (1871,) Calcutta.

THE SURVEY.

CHRISTCHURCH.—Journal of the Proceedings of the Provincial Council of Canterbury. Session XXXIV—(1871) fisc., Christchurch.

DR. HAAST.

" Laws of the Philosophical Institute of Canterbury. Founded 1862. Incorporated 1868—(1870) 8vo., Christchurch.

DR. HAAST.

" Philosophical Institute of Canterbury. Report of the Council for the year ending 31st December 1870—(1870) 8vo., Christchurch.

DR. HAAST.

COPENHAGEN.—Oversigt over det kongelige danske Vídenskabernes Selskabs Forhandlinger og dets Medlemmeers Arbeider i Aaret 1870, No. 2, (1870,) 8vo., Copenhagen.

DANISH ACADEMY.

DRESDEN.—Sitzungsberichte der naturwissenschaftlichen Gesellschaft Isis in Dresden. Jahrg. 1870, July, December (1870-71,) 8vo., Dresden.

THE ISIS SOCIETY.

Titles of Books. *Donors.*

FLORENCE.—Bolletino R. Comitato Geologico d'Italia, Nos. 5 to 6, (1871,) 8vo., Florence.

THE SOCIETY.

HAARLEM.—Verhandelingen de Commissie Geologische Beschrijving en Kaart van Nederland, Vol. I, (1853)—II (1854) 4to., Haarlem.

KÖNIGSBERG.—Schriften der Königlichen Physikalisch—Okonomïschen Gesellschaft zu Königsberg. Jahrg. XI. Abth. I.—(1871) 4to., Königsberg.

LONDON.—Journal of the Society of Arts, Vol. XIX, No. 956, (1871,) 8vo., London.

THE SOCIETY.

„ Proceedings of the Royal Geographical Society, Vol. XV, No. 1, (1871.) 8vo., London.

THE SOCIETY.

„ Proceedings of the Royal Society, Vol. XIX, Nos. 126 and 128, (1871,) 8vo., London.

THE SOCIETY.

MONTREAL.—Geological Survey of Canada. Report of Progress from 1866-1869—(1870) 8vo., Montreal.

THE SURVEY.

MOSCOU.—Bulletin de la Sociéte Impériale des Naturalistes de Moscou, Vol. XLIII, No. 2, (1870,) 8vo., Moscou.

THE SOCIETY.

MÜNICH.—Sitzungsberichte der königlichen Bayerischen akademie der Wissenschaften zu München, Band II, Heft. 1-4, (1870,) 8vo., München.

THE ACADEMY.

PHILADELPHIA.—Journal of the Franklin Institute, 3rd Series, Vol. LXI, Nos. 1-2, (1870,) 8vo., Philadelphia.

THE INSTITUTE.

„ Proceedings of the Academy of Natural Science of Philadelphia, Nos. 1-3, January, December, (1870,) 8vo., Philadelphia.

THE ACADEMY.

ST. PETERSBOURG.—Bulletin de l'Académie Impériale des Sciénces de St. Petersbourg, Vol. XV, Nos. 3-5, (1871,) 4to., St. Petersbourg.

VIENNA.—Denkschriften der kais-akademie der Wissenschaften, Band XXX (1870)—(1870) 4to., Vienna.

THE ACADEMY.

„ Sitzungsbericht der kais. Akademie der Wissenschaften.

Band LX,	Abth. I,	Heft. 3 to 5, Oct. to Dec. (1869.)	
„ LX,	„ II,	„ 3 to 5, Oct. to Dec. (1869.)	
„ LXI,	„ I,	„ 1 to 5, Jan. to May (1870.)	
„ LXI,	„ II,	„ 1 to 5, Jan. to May (1870.)	
„ LXII,	„ I,	„ 1 to 2, June to July (1870.)	
„ LXII,	„ II,	„ 1 to 3, June to Oct. (1870.)	

und Register zu den Bänden 51 to 60 (1871), (1869-1870,) 8vo., Vienna.

THE ACADEMY.

„ Jahrbuch der kais. könig. Geologischen Reichsanstalt, Band XXI, No. 1, January to March—(1871) 8vo., Vienna.

„ Verhandlungen der kais. könig. Geologischen Reichsanstalt, Nos. 1 to 5, January to March—(1871) 8vo., Vienna.

Titles of Books. *Donors.*

VIENNA.—Abhandlungen d. k. k. Geol. Reichs, Band V, Heft 1, Die Reptilfauna der Gosau—Formation in der neuen Welt bei Wiener Neustadt, von Dr Emanuel Bunzel.

„ Abhandlungen d. k. k. Geol. Reichs, Band V, Heft 2. Die Cephalopoden Fauna, der Oolithe von Balin bei Krakau, von Dr. M. Neumayr.

THE INSTITUTE.

WELLINGTON.—Transactions of the New Zealand Institute, Vol. II (1869), II (1870)—(1870-71) 8vo., Wellington.

DR. HAAST.

„ Proceedings of the New Zealand Institute, Vol. III, Parts 1 to 2, January to December—(1870) 8vo., Wellington.

DR. HAAST.

ZÜRICH.—Viertéljahrsschrift der naturforschenden Gesellschaft in Zürich. Jahrg. XIV. pts. 1 to 4, (1869,) 8vo., Zürich.

THE SOCIETY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1872. [November.

NOTE ON EXPLORATION FOR COAL IN THE NORTHERN REGION OF THE SATPURA BASIN, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

In anticipation of a detailed report of work in the Satpura coal basin, this notice is given of any results of practical interest. The coal mines of the Sitariva, and the explorations in connection with them as working from the only outcrop of the measures on the north-side of the Satpura basin, have naturally been looked to for information to guide us in estimating the chances of success in other analogous positions. In previous reports I have mentioned the disappointing want of information derived from this source, and I regret that the same disappointment has again to be expressed regarding the point upon which information was most needed—the extension of the coal seams to the south, towards the dip of the basin. A boring was attempted this year at the edge of the Sitariva, south of the present colliery; but it came to a stand-still at 194 feet, in the Máhádévá clay and conglomerate, short of the calculated depth at which the measures might have been struck. Upon this most important point, therefore, we still know no more than might be learned from the exposed outcrops. It was always upon success in this direction that the best prospects of the mining concern were considered to lie; so, to a great extent, it may be said that those prospects are as good as ever they were. The somewhat intricate stratigraphical features noticed in my detailed report of last season's field work may add some little anxiety as to the depth to which the coal may have to be followed; but practically this should at present only add to the urgency for vigorously prosecuting the exploration to allow for the opening out of a new mine in deep ground before the exhaustion of the very limited supply at present available.

Notice has also to be taken of a failure of a more positive kind in connection with the exploration of the field within the outcrop of the measures between the present mines and the north boundary of the basin. In reporting upon the field in May 1870, before anything had been done to try the ground, I stated the geological possibilities of the case thus :—"It may be said that there are about two miles of known outcrop, the coal being obscurely visible at the surface at several spots along the curved line between the two collieries, *but its thickness or its quality in that position has not been tried.* Assuming it to maintain a mean thickness of workable coal between the aggregates at the two collieries, say 25 feet, (at the rate of 1,000 tons per foot of thickness per acre of seam), we should have 400,000 tons for every ·66 feet down the seam along the whole length of two miles. As at many places the seam may be followed for many hundred feet, it is apparent that, without any very unwarrantable assumption, we may count upon a large supply of coal for many years to come." I observe in a recent report of the Narbadá Coal and Iron Company (published in the 'Mining Journal' for July 6th, 1872), use has been made of the last words of this quotation, without any mention of the conditions so pointedly attached to them, and without any notice of the unfavorable realization of those conditions as proved in subsequent trials and as already published in my report of May 1871 (Rec. Geol. Sur., Vol. IV., page 67). Some further trials during the past season in the same ground to the north of the mines have not resulted in anything more hopeful. Shallow pits and galleries were driven upon the outcrop in several places, but the seam, besides being greatly crushed, exhibits much original impoverishment, shale having to a great extent taken the place of coal. It is certain, however, that this change is only a local accident, not a steady northerly extension of the coal, for in the vertical seams still further north, in the abandoned mines of the Sitariva Company, the coal, though ruined by the crushing it has undergone, does undoubtedly represent a rich deposit.

This fact of rapid local change suggests an explanation of a very puzzling structural feature in the Narbadá Company's mine. It has been often mentioned how the massive bed of coal stops out on the north-east against a steep face of sandstone. Although there were little or no signs of friction, and sometimes not even of crushing in the coal, this feature was accepted as a fault, having, according to the ordinary rule, an upthrow on the north-east. On this supposition a gallery was driven across the bedding, the dip being north-easterly, to find the coal beyond the fault; shafts were also sunk on the hill above the fault on the north-east, but without any success. On the chance of its being a reverse fault, a boring was driven to some depth, the shaft of the mine under the river proving the same ground, but the seam was not found. It was thus plain that, if a fault, it must have a very considerable throw. Against this, however, some very strong *á priori* reasons were existent. The boundary of the two formations sweeps across the run of this supposed fault without any displacement, showing that the age of the fault (if it existed) must be older than the Máhádévá beds, and on the other hand the constant parallelism of the strata in the two formations, with great steadiness of horizon in the lower group at the boundary, would be almost incompatible with so great a disturbance affecting the lower group only. There is some direct evidence in support of these arguments; in the gallery and the shafts driven beyond the 'fault' in search of the seam, a quantity of hard black sandy clay with thin strings of coal was cut, for which, unless it represent the seam, no horizon could be assigned. I believe then that this is only a fault in the wider sense given to the term by miners of the nature of what is sometimes called a 'horse-back,' a thick drift of sand against which the coal deposit ended. An analogous feature occurs in the new mine on the lower seams; these stop abruptly against an east-west fault, of which a section is exposed in one of the road cuttings, showing certainly some slipping along the crack, but in the position of the seams beyond this small slip there is only found a band of coaly shale and even this dies out within a few yards.

Regarding the exploration of the Satpura coal basin in other regions, I would strongly recommend that efficient trial be made both in the Dudhi and Tawa valleys at some distance from the north boundary of the field. In my detailed geological description of the ground I notice some features which complicate very much the calculation of the depth at which the coal may be cut; indeed any estimate at present without any local precedent to guide one would be no more than a guess. The analogy of other Indian coal-fields, so far as known, is altogether in favour of the coal here being within a workable depth. I would recommend Budi, in the Dudhi valley, and the banks of the Suk Tawa, south of Kesla, in the Tawa region, as suitable places for trial borings. An analogous position might be chosen at Bichla on the Sitariva. All these places would be clear of the unfavorable conditions—coarse conglomerates, high dips, and copious trap intrusions—which increase the difficulties of exploration close to the boundary of the field, as has been so unfortunately experienced in the trials made by the Narbadá Company; the borings they have attempted to the south have 'come to grief' at small depths in the coarse conglomerate. The only inducement to keep near the boundary there, was to be more or less within known and calculable conditions. In choosing actual sites for borings in the positions now recommended, the point may be decided entirely with reference to the convenience of surface conditions for the operation, the geological data being so vague as to leave the exact point immaterial within a considerable range; only, give a wide berth to trap dykes.

The discussion of last season's observations on the north boundary of the Satpura basin has led to an inference of the possibility of coal being found in the Narbadá valley itself. Shallow borings through the alluvial deposits would show whether these were underlaid by the metamorphics, or by formations belonging to the coal series. I would recommend Gadurwara and Bankeri as suitable positions for this experiment.

H. B. MEDLICOTT.

August 1872.

NOTE ON THE VALUE OF THE EVIDENCE AFFORDED BY RAISED OYSTER BANKS ON THE COASTS OF INDIA, IN ESTIMATING THE AMOUNT OF ELEVATION INDICATED THEREBY, *by* WM. THEOBALD, *Geological Survey of India.*

In a paper in the Records of the Geological Survey, Part 3 of 1872, on the geology of the Bombay Presidency, Mr. Blanford quotes some observations made by myself in 1858, establishing the elevation of a portion of the Kattiawar coast during very recent times, and it is with reference to some of the evidence adduced in support of this assertion, and in order to correct an error caused by misreading of my notes, that I would here offer a few remarks. Mr. Blanford (*loc. cit.*), page 101, makes my estimate of the rise in the coast that took place in 1856 to amount to *ten* feet, a misreading for *two*, the words used by me being as follow:—

"Many of these oysters are seen with both valves attached, and evidently but recently dead; and as oysters of this size are never uncovered, I presume that an elevatory movement of at least *two* feet, and probably more, took place in 1856, the year when all the oysters in the creek were destroyed". Of course a clerical error of this sort is very easily made, and in this instance the actual amount of elevation that took place may in reality have been nearer ten than two feet. The evidence, of course, of the occurrence of oysters of a sort never exposed by spring tides above low water mark is conclusive, but does not permit a very exact gauge as to its amount. There is, however, another point connected with the question on which I would record a caution. There are on the coasts of India three species of oysters which are likely to be made use of in determining questions of littoral elevation, *viz.*, the creek oyster, the shore oyster, and the rock oyster. The creek oyster is a large species something like the fossil *O. lingula,* Sow., and possibly, Dr. Stoliczka thinks, identical with *O. Talienwahensis,* Crosse, and attaining occasionally the length of a foot. It is excellent eating and universally esteemed, but it is only procurable at the springs, as it rarely occurs in less depth than a little below lowest spring tides, and never, as a rule, above that level.

The second species is, in my opinion, merely a variety of the last, and Mr. Hanley, to whom I submitted specimens, declared they were barely distinguishable from the European *O. edulis,* L. This species occurs sporadically between tide-marks both on the coast of Kattiawar and the eastern shores of the Bay of Bengal, in common with both the other species, and from its sparse mode of occurrence is, in my opinion, merely an abnorma form of the first, reduced in size and altered in appearance by the uncongenial surrounding amidst which it has been developed. A specimen collected by myself of this form is figured as *O. nigremarginata,* Sow. in Conch. Iconica, Plate XXXIII, 84. The third species is the little slipper oyster *O. cucullata*, Born, which is seen crusting every surf-beaten rock wherein little else save a limpet or barnacle could make good their hold. This oyster is eaten largely, and is generally wholesome, but as it occurs in creeks and spots where it becomes subjected to very unnatural conditions a little caution should be exercised, as under circumstances it becomes, I believe, unwholesome. In places exposed to the open sea and the roll of the breakers, it would seem to flourish vigorously anywhere between tide marks, but in more sheltered spots its proper range seems to be lower, although its vitality is such that there seems to be no spot to which the fry can gain access, whereon they will not grow to maturity. As an instance of this I will mention one case on the Arakan coast, where I noticed this species growing at the extreme (neap) high water level; indeed I may say above it, where the oyster could never have obtained two hours continuous immersion at any time, and that only during a few days in the month whilst for many days together it must have remained with its valves closed The spot where this was noticed by me was a small island off the coast on its sheltered side. The rocks were sandstone and there was no shelter from the sea. I landed at high water (neaps), and the oysters I saw along the margin of the water were, it seemed to me, dead judging from that position. On knocking off one, however, with a hammer, I found it was alive, and on putting it into my mouth remarked that it felt unpleasantly warm. From this we may draw the conclusion that in investigating a raised beech or littoral tract the evidence afforded by the presence of the small *O. cucullata* only reaches conclusively to demonstrate the difference between the spot raised and *high water* mark, and that without additional evidence no greater amount of elevation can be deduced therefrom; whilst the presence of the larger creek oyster in any raised deposit may be held to establish the elevation of the spot it occupied to the full amount of the interval between it and *low water* mark. In all accounts, therefore, wherein oysters are recorded as raised, it is very important to obtain specific information as to *which* oyster is meant, the difference involved in the discrimination amounting to the entire height to which the tide rises in the locality in question.

NOTE ON A POSSIBLE FIELD OF COAL MEASURES IN THE GODÁVARÍ DISTRICT, MADRAS PRESIDENCY, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

About twenty miles to the westward of Rájámahindri there is a great area of brown and red *Kamthi* sandstones, &c., which was very rapidly examined and subsequently described by Mr. W. T. Blanford.* One of the desiderata of this examination was to ascertain if any further indications of underlying coal-bearing rocks existed than those already known on the Godávarí river, but Mr. Blanford was only successful in finding a small field of these, to which he refers as follows:—"In only one place was any rock seen which had a distinctly *Barákar* character. This lies south of the village of Bedánol, nearly due east of Ashraopetta, in a stream, and even in this case the rock was only white felspathic grit unaccompanied by shale or any other typical *Damuda* formation."

During the latter part of the working season just concluded, I have had an opportunity of going more closely over so much of Mr. Blanford's area as lies within the Godávarí and Kistna districts, but still without having found any other locality than the one pointed out by him. Neither could I, here, find any trace of coal, nor is there any knowledge in the neighbourhood of its ever having been seen. There is yet, however, the possibility of a seam being found by closer search, considering that there are in the stream

* Rec. G. S. of I., 1871, page 4, 1872, page 1.

courses numerous sand-filled gaps between outcrops of rock which may be scoured out differently every season and may thus show coal which we have missed *.

The absence of shale, as noticed by Mr. Blanford, is not necessarily of material consequence, as local experience shows, for no shales are exposed in either the Singareny, or Pungady Vagu (Kamárum, Nizam's dominions) fields, the coal seams in both cases being sharply interstratified with sandstones.

This being, up to the present, the only known locality in the Madras Presidency Proper of sandstones belonging to the Indian coal-bearing rocks, it possesses more interest than it possibly deserves from the small extent of the field and absence of any absolute indications of coal. On this account, as well as because it may be found advisable to try the field by boring, the following short details are given.

The field of these Beddadanol beds is about 5¼ square miles in extent, being situated on the head waters of a large feeder of the Yerra Kalwa, with the village, or rather few huts, of Beddadanol in its midst. It is some thirty-eight miles west-north-west of Rájámahindri, and about four miles or so from the boundary of the Nizam's dominions near Ashwarowpetta. The nearest large village, Gunnapawarum, lies a mile and half to the south. The area of sandstones is itself covered by thick tree-jungle and very thinly populated.

The strata extend for some width on either side of the river; on the left there is a width of little more than a mile, with a length of something more than four miles, while the patch is narrower on the right, being about a mile wide in the middle and thinning off to the north and south. The rocks are thick and thin bedded, coarse felspathic sandstones, rather friable, of white or pale grey and buff colors, weathering much darker. They occasionally exhibit ferruginous concretions on the weathered surface like the sandstones of the same group at Lingála on the Godávarí. Generally, the resemblance to the sandstones of the Singareny coal-field is most striking. The dip is, as a rule, south-west or westwards at low angles of 2°, 5°, 10°, and there are occasional undulations.

In the small stream south of Beddadanol there is a tolerably continuous outcrop of sandstones, having a general dip of 2°—5° to south-west, with frequent easy rolls all down the bed until it debouches on the main stream. Very much the same kind of section is seen up the nullah north of the village, and again in a side stream further north. In the main river there are frequent outcrops of these sandstones below the junction of the first feeder mentioned above, and away in the jungle on either bank: but the best outcrops are seen higher up at the watering place north-west of Beddadanol, and thence upwards along the river course. Here there is a good deal of sandstone displayed on either side of the stream in thick beds, having an easy dip to the west. These are overlaid by a more compact and hard brown bed which seems to mark the change upwards into *Kamthi* beds, as it is succeeded by thinner yellow strata, and then by the red purple and brown beds so characteristic of that series in this part of the country.

It is very difficult to estimate the thickness of the *Barákars* as developed in the area under notice, owing to the frequent rollings of the strata; but as far as could be made out on the three stream traverses of the Beddadanol side of the field, there must be at least 300 feet without reckoning the strata on the other side of the river which are not at all so clearly seen.

* As an instance of the rarity of exposure of coal seams, the case of the Singareny (See Rec. G. S. of I., vol. V., part 2) coal field may be cited, the seam having only become exposed by the merest accident of the water in the stream being so low.

To the west of the field, the land rising to the low flat-topped hills of Perrumpoodee, &c., is all made up of *Kamthis*, under which the Beddadanol *Barákars* may extend for any distance, though they will—if such be the case—be at too great a depth to justify mere trial boring, unless some better evidence of coal can be obtained from the sandstones now exposed. Along the eastern edge of the field the strata are lying directly on quartzose gneiss, without any interpolation of *Talchirs*. Indeed, around the edge of the whole of the area in the two districts now referred to there is no occurrence of these latter rocks; the *Kamthis*, except in Beddadanol neighbourhood, resting on *gneiss*.

On the whole, it is very much to be feared that there is here only a small patch of *Barákars* which does not extend far under the *Kamthis*; so that, if coal were eventually struck, the quantity would be so small as to be merely sufficient for local use. According to all the observations and conclusions of my colleagues who have worked at the coal rocks of India* it seems pretty clearly established, that the *Damudas*, so extensively developed in Bengal, became of less and less importance to the west and south-west, the Raneegunge beds eventually being entirely absent or represented by rocks containing no coal, until there was only a series of small outlying basins of the lowest group or *Barákars* deposited on the lower part of the Godávarí valley which now remain as the coal-fields on the Pungady Vagu (Kamárum) and at Singareny, and last the sandstones of Beddadanol. On the other hand, the *Kamthis*, considered to be in part at least representative of a higher series (*Panchet*) have thickened out greatly in this direction, and constitute the great area of sandstones to the north of Ellore and west of the Godávarí; which have in no case been found to contain coal.

There may, of course, be other patches of *Barákars* under this spread of *Kamthis*, but it would be working on mere chance, and at a most enormous cost, to attempt to pierce at random through this thick series on the expectation of striking on any hidden coal store. The succession of these *Kamthis* is so clear one bed under the other for the whole distance across the strike from south-west to north-east, at a varying dip of 5°, 10°, 20°, to the south-west, without once a sufficient undulation to bring the bottom beds nearer to the surface than they can be struck along the north-east edge of the field, that all borings would run to an enormous depth. The only locality where at one time there appeared the slightest chance of finding lower beds brought nearer to the surface was in the Ponakamaud Station range of hills, about 24 miles due north of Ellore, but it was soon found that the strata on the north-east slopes of the range were still underlaid by many hundreds of feet of beds of the same series.

Nevertheless, the finding of coal in the Madras Presidency is of such vital importance that it seems advisable to have a series of borings made in the Beddadanol field. A very few trials, and these of no great depth, possibly not more than 300 feet at the most—and even this depth could to a great extent be avoided by putting short bore-holes down in a line across the strike—would settle a question liable to crop up continually so long as it was believed that sandstones of the coal measures existed in the Godávarí district which had not been explored in this way. Boring tools could probably be obtained from the depôts on the adjoining Godávarí works, and possibly competent parties to take charge of the trials.

WILLIAM KING.

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* See Rec. G. S. of I., part 3, vol. IV.

NOTE ON THE LAMÉTA OR INFRA-TRAPPEAN FORMATION OF CENTRAL INDIA, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Recent work enables us to record some fresh observations regarding the formation denoted in the publications of the Geological Survey as the Laméta or the infra-trappean group of Central India. Although never more than from one to two hundred feet in thickness it has a wide range, occurring continuously for great distances along the eastern base of the Deccan trap; from the Narbadá valley round by Amarkantak to the Nagpúr and Chandá country. It is principally of interest for the evidence it may give as to the age of the great volcanic formation with which it is so closely connected. Its position in this question is apparently conflicting, and offers an interesting test of the independent application of palæontological determinations. Examined from the east these deposits would certainly be (and have been) identified with the very similar inter-trappean beds occurring in the adjoining sections; and these have been considered to be Eocene. This opinion was first formed from the *facies* of the fresh water and terrestrial fossils, which are the only organic remains found in these intertrappeans in the upland country; but it has received support from the examination of the few marine fossils found associated with the others in the distant outlier at Rájámahindri near the mouth of the Godáveri. This position is geographically related to that of the upper cretaceous deposits of Trichinopoli; but Dr. Stoliczka has found that the marine fossils of the Rájámahindri inter-trappeans are distinct from any occurring in those topmost cretaceous deposits. On the other hand, examined from the west, up the Narbadá valley, the Laméta beds would be (and have been) connected with the infra-trappean deposits of Bágh and Barwai, and these are cretaceous (Middle Cretaceous according to Dr. Martin Duncan, Quar. Jour. Geol. Soc., London, Vol. XXI, p. 349).

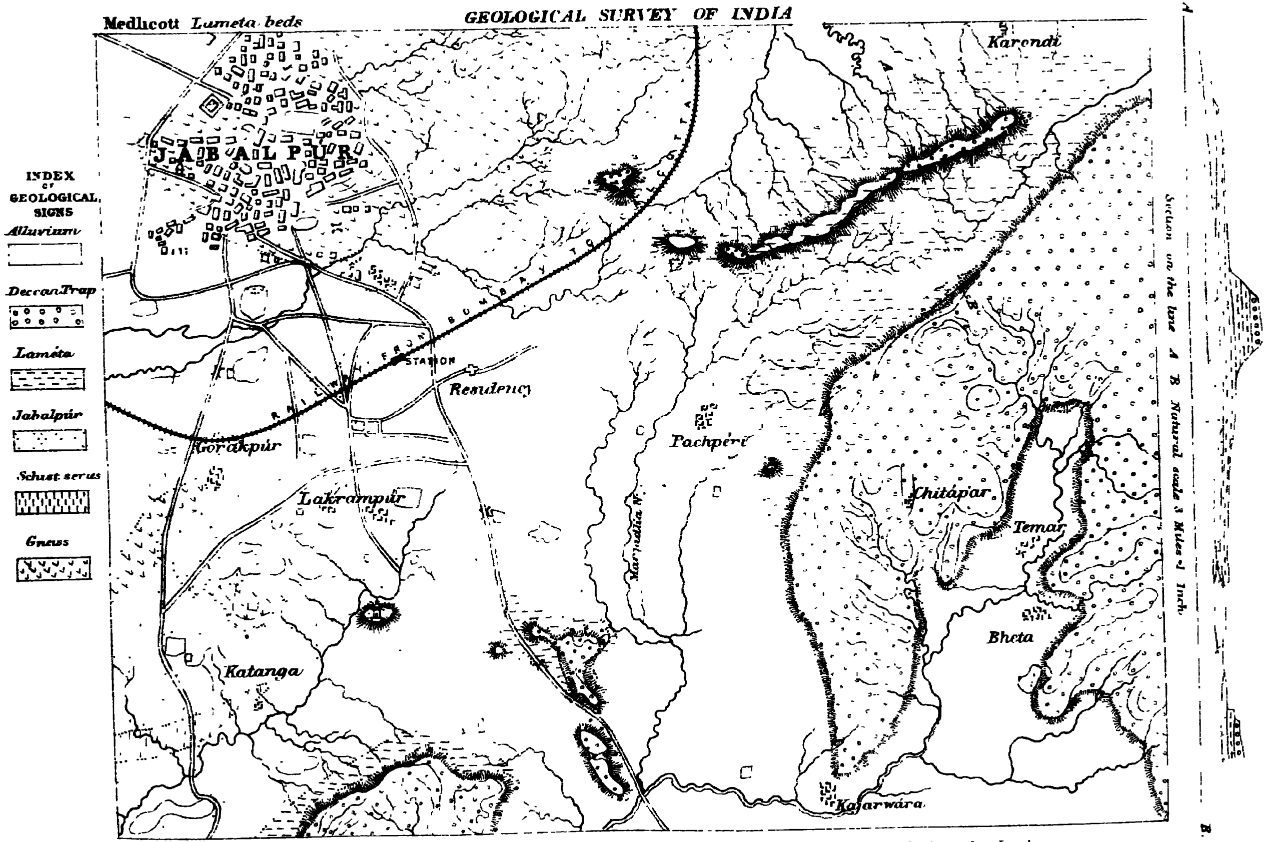
The last discussion of this question was by Mr. W. T. Blanford (in Vol. VI, Mem. Geol. Sur., pp. 156-160 and 207-218, and Rec. Geol. Sur., Vol. V, pp. 88-93), and a strong case was made for the correspondence of certain infra-trappean deposits throughout the Narbadá valley. Mr. Blanford's remarks upon the eastern area were not all based upon his own observations, but partly upon previous work of old date on the Narbadá coal-basin (l. c., Vol II), in which it was conjectured that the Laméta beds on the east might be the equivalent of the Máhádévá sandstones of the Pachmari hills. He was thus led to assimilate the calcareous portion of the Bágh series and the sandstones conformably underlying them to the Laméta limestone and to the Máhádévá sandstone respectively. Recent detailed work has shown that all the rocks known as Máhádévá in the Narbadá region belong to a great plant-bearing series, the youngest member of which is the Jabalpúr (jurassic) group; the Laméta deposits being totally unconformable to this group. This separation of the Laméta and Máhádévá groups is so wide that were Mr. Blanford's conjectural identification of the sandstones confirmed, it would give very strong presumption of the separation of the two limestones; but it was upon the correspondence of these that Mr. Blanford laid most stress; and for them the case stands much as he left it; the stratigraphical break between the cretaceous deposits of Bágh and the trap overlying them being much less marked than the break between the trap and the nummulitics of Súrat and Bharoch. Mr. Blanford was disposed to consider the volcanic formation to be more nearly cretaceous than tertiary. The comparison of the Rájámahindri fossils had not then been made, but Mr. Blanford, to some extent, anticipated the result by saying that "exact specific identity can scarcely be expected, the Rájámahindri band being, I think, estuarine, while all the Trichinopoli beds are purely marine." The separation of the Lamétas from the intertrappeans has not lately been contemplated by any one; Mr. Blanford notices (l. c., p. 216,) how undistinguishable they are lithologically; and, of course, the confirmation of their close affinity would be a link in the chain of evidence be brought to bear upon the age of the eruptive rocks. Thus the solution of this interesting question seems closely connected with the determination of the correspondence of the Bágh beds and those similar deposits on the same infra-trappean horizon.

The Lamétas, though so much more extensively developed than the intertrappeans, have yielded comparatively few fossils. Vertebrate remains, some very large, have been found in them at Jabalpúr, and elsewhere some shells, establishing the fresh water origin of the group; and so far, its *primâ facie* connection with the intertrappeans. One would then naturally go on to apply the same explanation to the formation of this fresh water basin as that given by Mr. Blanford for the intertrappeans, namely, the stoppage of local drainage by the outflow of trap. This would at once annex the Lamétas to the trappean formation. The great comparative continuity and extent of the Laméta deposits presents some difficulty to this supposition; the conditions would rather suggest some more general cause, such as tilting of the surface, by which the drainage of a large area would be thrown back, and the direct evidence which might be looked for to connect them with the trap is wanting. There is not a single instance known throughout this extensive formation of a bed passing from it over and between trap flows, although it is very common to find trap close to thick Laméta deposits, and at a lower level. This circumstance involves considerations, some of which have an important bearing upon the relations of the two formations, implying, as it does, either (1) abrupt inequality in the Laméta deposits; or (2) considerable pre-trappean denudation; or (3) disturbance of the deposits, whether before or after the advent of the trap. The principal object of the present paper is to illustrate this feature of the case.

The Laméta group is well exposed in the immediate neighbourhood of Jabalpúr. The undulating ground to the east of the station is on the thick soft sandstones and pale shaly clays of the Jabalpúr group; the flat hills beyond being of the Laméta beds, capped by trap. On the little ridge to the north-east of the station, the Lamétas show their greatest development, being about 150 feet thick. The south-west summit of this ridge, locally called Chota Simla, is capped by about 20 feet of trap; and on the north-east, where the Trigonometrical Survey Observatory Station is erected, there is a crest three-quarters of a mile long formed of trap, to a thickness of about 50 feet. This ridge quite overlooks the trappean plateau to the south-east, from which it is partly separated, on the west, by the valley of the Marjadlia stream, cut through the Jabalpúr sandstone, the base of the Lamétas here being close under the steep rise of the ridge. This level is maintained by the junction along the little valley, at the head of which the trap of the plateau rests upon the Jabalpúr group, thus giving a strong case of apparent unconformity, the whole 150 feet of Lamétas disappearing within a distance of half a mile, at the level of the bottom bed. South of the little valley the Lamétas come in again at first only 5 to 10 feet thick, but increasing gradually to the south, the base of the group sloping down under the alluvium in a length of about one mile and a half.

Regarding the junction of the Laméta group with the Jabalpúr beds this section gives apparent presumption of unconformity. It would be difficult to give clear evidence on this point from this locality, on account of the massive irregular structure of the Jabalpúr deposits; and it is evident that such features as those described might be caused by a slight undulating disturbance of two conformable groups, followed by denudation before the advent of the trap. There is, however, ample evidence elsewhere of the discordance of the Jabalpúr and Laméta groups; the latter passing indiscriminately across the former, and even here, at the east base of the observatory hill, an inlier of Jabalpúr sandstone is weathered out from the surrounding Laméta limestone.

Medlicott Lameta beds



MAP of NEIGHBOURHOOD of JABALPUR. Scale 1 Mile =1 Inch

But it is the upper junction that we are now concerned with. For this case the supposition of slight disturbance and considerable denudation of the Lamétas, both pre-trappean, is *primâ facie* suggested by the section described. It is desirable, though difficult, to keep separate the argument for those two operations. If the supposition of disturbance be excluded, thereby leaving the present under-surface of the Lamétas the same as at the time of deposition, it becomes almost necessary to suppose that they extended in greater force than we now find them over the ground to the south, and hence that they were removed before the overflow of the trap; for, it is difficult to imagine how, in a small area, the thickest deposits could be accumulated on the highest ground, much of them being composed of fine sand and clay. It is not either a uniform thinning to the south; for in that direction they thicken again before passing under the alluvium. If we are to explain the great contrast in thickness to the north and the south of the little valley by the presence, at the time of deposition, of a ridge of Jabalpúr sandstone in the position of the present valley, the fact of pre-trappean denudation would be equally established, for the trap now rests on the sandstone, at the head of that valley, at the level of the bottom beds of the Lamétas. If, on the other hand, we explain the fact of the deposits being at present thickest on the higher ground, by supposing a change of level subsequent to deposition, it would be possible to dispense with denudation, and we should be called upon to decide whether the disturbance occurred before or after the out-pouring of the trap. The very rough structure of stratification in volcanic rocks would make it very difficult, indeed, to find conclusive evidence for or against this position. It can only be said that the general distribution of the Laméta deposits suggests a slight relative change of level since their formation; and that the only direct observation bearing upon this point seems to show that the trap did not participate in that movement: at the base of the low scarp east by south of the village of Pachpéri there is a marked apparent dip of the Laméta limestone by which the trap does not seem to be affected; on the contrary, the level is maintained by a thickening of the sand overlying the limestone. This dip is spoken of as 'apparent,' because the original irregularities in the Lamétas are so rapid that one cannot be certain that the feature here was really induced by disturbance.

The internal evidence of the Laméta deposits throws some light upon these general considerations. No constant sequence or composition could be given for the group. A limestone is its only general characteristic; sometimes forming the whole of the band, sometimes quite subordinate in detrital deposits. All these conditions are illustrated at Jabalpúr. At the point of Chota Simla hill, and on the outlier to the west of it, the section is as follows:—at base is a thick, false-bedded, fine, porous, friable sandstone, pale, generally of a green tinge, sometimes a deep glauconite green (but not from green grains), locally purplish and mottled. At top it is much mixed with fine laminated clay, which again passes into earthy, dirty, pebbly, sandy limestone. It is in this bed and locality that vertebrate remains have been found. This limestone is here overlaid by fine crumbling sandy clay, pale purple mottled by green. Sandy layers are frequent, also strings of nodular limestone. The top limestone is a development of this tendency: it is prominently sandy, and is overlaid by sand. The crest of the ridge between the two terminal cappings of trap is formed of this upper limestone. To east of Chota Simla the lower limestones thicken greatly, replacing the bottom sand; and the whole section varies indefinitely. Under the trap on the observatory hill the top sand is well developed; a peculiar rusty, soft, fine-grained rock, quite devoid of earthy matrix; very like a common form of decomposing Jabalpúr sandstone, but quite unlike the usual sands of the Laméta group. This peculiarity makes it very useful in revealing the internal arrangement of the group, as it happens to be pretty generally distributed in this neighbourhood. Thus, on the south side of the little valley of the Marjadlia (see the figured section) there is a scarped terrace formed of a single strong bed, 10 to 15 feet thick, of Laméta limestone, resting directly on the sandstones and clays of the Jabalpúrs; and upon it rests the trap, forming a second scarp; only at two or three spots one finds between these a remnant of a sand identical with the top bed on the observatory hill. In normally bedded rocks one would *primâ facie* conjecture from such a section that the limestone here was the upper band of the ridge, requiring, of course, for the non-appearance of the lower beds, the supposition of original overlap, with subsequent change of bed. On the ground, however, one cannot resist the conclusion that the limestones facing each other on opposite sides of the little valley are the same band, they so exactly correspond in every character; so that one is forced to account for the discrepancy otherwise, by the absence of all the middle beds of the ridge. The identification of the limestones on opposite sides of the valley, and their exact correspondence in level, sets aside the introduction of any abrupt change of bed at this point, so that the difficulty at first brought to notice of supposing the original dying out of such deposits as those of the middle beds of the ridge meets us now within the Laméta group itself; and the contrast of thickness and of level is so great that one has to suppose a contemporaneous denudation to have assisted the irregularity of deposition, so as to admit of the top and bottom beds of the group coming together within such a short distance; a general undulating disturbance having still further increased the apparent anomaly of the actual features.

The considerations stated in the last paragraph, by bringing the chief discrepancy within the group itself, would seem to dispose of the main point at issue—the unconformity of the trap on the Lamétas. But such is not the case, even for the particular section under notice. The top sandstone is in force on the observatory hill, and again so to the south of the Pachpéri flexure; and it continues so beyond the Marjadlia valley to the south-west. On the Pachpéri terrace, however, between the two first of these localities, one finds the nearest remnants of it, and this only locally between the trap and the limestone. Its absence is most reasonably accounted for by denudation.

There are some local sections near Jabalpúr independently involving the conclusion of a pre-trappean denudation of the Lamétas. The ridge on which the European hospital stands is formed of Laméta limestone. In the river, a quarter of a mile to the east, the limestone associated with mottled sands reaches from the water's edge to some 50 feet on the hill-side. In both positions there is a capping of trap; but between the two, on the north face of the rising ground, the trap reaches to a lower level. Again, in the reverse valley, to the north-east of the Marjadlia water-shed, the trap reaches nearly to the stream on the south-east side, at a much lower level than the Laméta limestone within a few yards of it on the north-eastern spur of the observatory ridge.

The views illustrated in the foregoing remarks upon the sections at Jabalpúr are briefly these: that the Lamétas are clearly pre-trappean; that there is good evidence for a slight pre-trappean disturbance of that group; and, that there is conclusive evidence for pre-trappean denudation.

The local denudation of the Laméta group would not be of much significance as an indication of any partial separation of it from the trappean formation; for, as Mr. Blanford has himself shown, the inter-trappeans have also suffered denudation before their inclusion by the trap. Mr. Blanford indeed, did not propose any separation of the Lamétas from the inter-trappeans, but rather, through their connection, to establish the cretaceous, rather than the tertiary age of the trappean formation; the correspondence of the Lamétas with the Bágh beds being the point he most insisted on. And, certainly, the petrographical homology of these groups is very striking. The considerations here offered tend to confirm that identification.

The denudation of the Lamétas seems to have been much greater to the west than to the east. From Jabalpúr they can be traced continuously for great distances round the Mandla plateau. That so moderately thick a formation should be so unbroken proves, at least, that the basin in which it was deposited was not there laid dry for any considerable period before the advent of the trap; if it does not indeed establish a closer connection with the volcanic outburst. It is very different to the westward: in going along the Narbadá valley gaps become more and more frequent, and of greater length. In most of these cases it is demonstrable that the deposits are only denuded remnants, the volcanic rock frequently appearing close by at a lower level.

The most westerly occurrence of these patches of Lamétas—that can, at least, be included with the main area of that formation, there being a break of 130 miles on the south side of the valley between it and the infra-trappeans of Punása and the Dhár Forest—is deserving of special notice for the peculiarity of its position, and because large vertebrate remains, though scarcely perfect enough for identification, have been found in it. It is not even quite certain that it is Laméta, because the supporting rock is not visible; but the lithological characters are so marked as to give much confidence in the identification. It forms a small inlier, weathered from beneath the trap in the bed of the Shér river, under the village of Kareia. There is a deep pool in the river, on the up side of which massive trap forms a steep fall; while on the down side of the pool, twenty yards across, these Laméta beds rise abruptly, having a small dip down stream. The trap appears in the bank above them, resting on a highly baked red sandstone, the top surface of a greenish earthy rock, which is confusedly associated with a more ordinarily pebbly sandstone and with a sandy pebbly limestone; a total thickness of about 15 feet. Within about fifty yards the trap again occupies the bed of the river, and some eighty yards lower down the water cuts a narrow gorge through massive Jabalpúr sandstone, for about two miles. The crossing trap seems to be part of the same mass as that facing the strata on the opposite side of the pool: thus implying a steep face of denudation. If this patch of Lamétas was ever continuous with the main area, it must have been through valleys now filled up by trap, for it is separated from the present Narbadá valley by a broad raised area of Jabalpúr sandstone. In this region the Lamétas do not intervene between the trap and the Jabalpúrs, even at very small elevations.

If it be assumed that these patches of Lamétas are indeed remnants of a once continuous deposit, this feature of denudation in the western region becomes a very important one. At present I see no escape from that conclusion: these patches are all on the same approximate horizon, and there is in most cases no assignable reason for their original limitation as local basins. The suppositions of once intervening marks of older rocks would equally prove the great denudation. I think, moreover, we are hardly at liberty to suppose these local basins to have been determined by intervening trap-flows, for the reason already stated, that no single case has been observed of Laméta beds overlapping, however steeply, on trap.

It is important to notice a precaution that must obviously be taken in applying this crucial test of the pre-trappean horizon of the Laméta beds. The Deccan trap is found in different regions of its very extended border resting upon metamorphics or other old formations at every level, from the moderate elevation of the Narbadá valley up to the highlands of the Western Ghâts. Its local base must, therefore, be presumed to be of different horizon in the formation at these different localities. It must so happen that on the horizon of the inter-trappean deposits, these should occasionally lap freely over the trap, on to the adjoining rocks; and they would, moreover, in such positions assume the sandy, pebbly character so common in the Lamétas, and so rare in the strictly inter-trappean basins.

There though locally infra-trappean, these beds would, of course, belong to the inter-trappean horizon. In his sketch of the Geology of the Bombay Presidency (Records, Geological Survey, Vol. V, page 93), Mr. Blanford notices some cases of this kind, as observed by Mr. Foote in the Kaladgi and Belgaon districts. The fact that in these exceptional positions the deposits contain the usual fossils of the inter-trappean beds only brings into greater contrast the prevailing absence of such remains in the much more largely developed deposits of the Laméta group; and also the occurrence of these overlaps in the comparatively restricted inter-trappean deposits gives some warrant to the demand for their production in the case of the widely extended Lamétas before these can be accepted as cotemporaneous with the trap.

August 1872.

A BRIEF NOTICE OF SOME RECENTLY DISCOVERED PETROLEUM LOCALITIES IN PEGU, *by* W. THEOBALD, *Geological Survey of India.*

In the third number of the Records of the Geological Survey for 1870, a brief notice is given by me of the occurrence in Pegu of petroleum at the then newly discovered locality of Pudouk-ben near Thaiet-mio. Since that date two other localities have been the scene of a not unsuccessful search for petroleum, the main facts connected with which I will here review.

The first locality visited by me is situated eleven and a half miles west of Prome Pagoda in a small stream falling into the Boogoo river, and three miles above the village of Toung-bo-ji, on the same small stream, which has no name applied to it on the published maps, but is locally known as the Mahu-choung.* This spot lies within the area of the unaltered nummulitic rocks, and is situated in a belt of undulating jungly ground, characterised by a general absence of water, and wherein, consequently, no villages exist, the scarcity of water appearing to depend on the impermeable character of the clays, which here mainly form the surface of the country. No good section of the beds is seen between Prome and the Mahu-choung, and the passage from the impermeable clays of the newer tertiaries to the similar beds of the nummulitic group is obscure and unindicated on the jungle clad surface of the ground by any obvious physical sign. The cause of this is the absence here of the nummulitic limestone, the highest member of the group, and, where present, an excellent horizon for the newer group; but this rock has here died out, and in default of good sections, the boundary of the two groups is thereby rendered indistinct.

The petroleum was first detected by some squatting families of Cutch-boilers, who settle in this arid tract as long as surface water is procurable in the small pools and watercourses in it, and these men remarked that in some spots where the water was very low and on the point of drying up, it possessed a flavor of petroleum. The presence of petroleum was, I am informed, noticed as a film on the water, where a dam had been thrown across the Mahu-choung near the village of Toung-bo-ji, below the spot where petroleum has since been obtained.

An enterprising and intelligent Chinaman possessed of a little capital determined to test the value of these surface indications, and sank some shafts along the course of the stream and on a line having an east by north bearing of less than one hundred yards in length. The most promising shaft, No. 2, was sunk in the bed of the stream, which was artificially deflected round it, and was carried to a depth of over 40 feet, through light-

* *Choung* = river or stream.

bluish clays containing Foraminifera (*Triloculina* or some allied form), but few other fossils, and evidently an homogeneous deposit formed in still water. The clay has not been pierced by the shaft, and, though yielding petroleum, does not appear to be the source or mother bed of it. I judge then from the petroleum appearing to line cracks and interstices in the clay rather than to be disseminated through it, as may be seen by fracturing the larger pieces, which, though superficially imbued to a small extent, do not seem to be equally permeated by it throughout, that it seems probable that the true naphthagenous beds of the group have yet to be reached. Into this shaft petroleum trickled at something like two gallons a day, till it became filled with water and was abandoned during the monsoon.

It may at first sight seem a curious thing that no more petroleum escaped into the shaft after it had become full of water; but I think a sufficient explanation of this lies in the mode of stowage of the petroleum in the rock. The oil occupying minute fissures or partings in the clay escaped by mere gravitation into the shaft as long as it was kept clear; but became at once arrested in its course, and, so to say, ponded back when met and opposed by the pressure of a column of water of 40 feet.

I have since heard that the shaft has been re-opened and deepened, and that thereon the petroleum recommenced to flow, but the ultimate results of the experiment I am unable at present to ascertain.

Bau-byin.

The second locality near the village of Bau-byin (Pau-fyeng in map) is situated some twelve and a half miles west-north-west from the circuit house at Thaiet-mio, and about a mile above the village, which is on the banks of the stream, which falls into the Irawadi a little above Thaiet-mio. It is moreover distant about four miles north-east of the Pudouk-ben locality, previously noticed in the Records for 1870.

In the neighbourhood are several spots where indications of petroleum occur, all in beds of the newer tertiaries and on pretty much the same horizon therein. Bluish shales are the predominant beds here, interspersed with sandstones; and fossils are not rare throughout of the ordinary aspect of the fossils of this group, sundry species of *Arca, Pecten, Isocardia, Ostrea, Solen, Cypræa, Conus, Turritella,* with crustacean remains and shark's teeth, having been procured by me in the vicinity.

In the stream about a mile above the village, the blue shales are exposed in a steep bluff undercut by the river, and a brown colored patch near the level of the stream indicates the extent to which the infiltration of the shales by petroleum has here reached. A little below this point a feeble escape of petroleum takes place into the stream from an orifice at about its ordinary dry season level. Close to this point a bed of sandstone with a dip of 70° south comes in, demonstrating a somewhat abrupt downthrow of the shales, which higher up stream are gently undulating, and the presence of this bed has not improbably determined the escape of the petroleum at this point, by opposing an obstacle to its upward progress, or permeation.

A shaft was sunk on the precipitous bank of the nulla, and a little petroleum obtained from it, but the site was bad, as it is scarcely possible to prevent the stream from cutting away the bank and destroying the work. About half way between the banks of the stream on the curve, I recommended a trial shaft should be sunk, the selection being made with reference to the position of the presumed extension of the bed of sandstone noticed above, which it seemed to me undesirable to try, but beneath which a certain supply of oil may be with some confidence looked for. Its escape into the stream, and its diffusion among the shales a little higher up the stream, with other indications at no great distance, render a search for the oil here rather less a matter of speculation than is usually the case. One thing is remarkable, and that is, on the supposition as advocated by me, that the naphthagenous beds are members of the nummulitic group. A great thickness of beds, not perhaps less than 2,000 feet, must be interposed between the source of the oil and its point here of natural discharge. These beds are more or less porous, and may hereafter possibly prove sufficiently rich in petroleum for profitable working, or possibly for purposes of distillation, but nothing but an experimental shaft will satisfactorily settle their economic value.

The petroleum from the above localities is very similar and more fluid than the commercial or Yenan-choung oil, a difference depending, probably, more on the length of time either has been exposed to the air than on any difference in chemical constitution, but no exact analysis has yet been made.

CORRECTION REGARDING THE SUPPOSED EOZOONAL LIMESTONE OF YELLAN BILE.

See Rec. G. S. of India, Vol. V, part 2.

Specimens of this limestone were sent home to Professor William King, Sc. D., of Queen's University of Ireland, for examination, which has resulted in the opinion that there is no eozoonal structure evident. Dr. King states that the rock consists of layers of two or more silicious minerals, and others containing calcareous matter; the former being in general the thickest and most abundant. The silicious layers are of a pale dirty green color. Examined with a good magnifying power, they are seen to be made up of rough grains of grey quartz and flattened particles of a greenish amorphous substance which appears to be chemically related to some amphibolic mineral; both kinds are generally compacted together by themselves, but occasionally calcareous matter is intermixed with them. Here and there the layers are reddened with an iron oxide. The calcareous layers, of a dark bluish green color, are charged with the prementioned grains and particles, principally the latter, and often to such an extent as to become essentially silicious. "In all cases the calcareous constituent is in the amorphous condition, neither saccharoidal nor crystalline, resembling that of ordinary blue-grey limestone.

"Examined after decalcification, the microscope shows the silicious layers intact except where they contain calcareous matters; in this case the component grains and particles, instead of being closely adherent, are separated by interstitial vacancies. The calcareous layers which are etched out to a slight depth exhibit a large number of the green flattened particles, and usually a smaller number of the quartz grains standing out in relief in the undissolved portion, and generally lying lengthways and parallel to the silicious layers. The components of the latter layers also affect a parallel arrangement.

"The rock, strictly speaking, cannot be called metamorphic. It resembles in texture some of the imperfectly developed gneissodes common in Connemara. The thickly laminated portions have all the appearance of being depositional in their origin. But often there are thin laminæ folding round nuclei, seemingly concretionary, which appear to be the result of supervened agencies. It was a specimen of the rock in the latter state that was decalcified.

"The interlamination of the silicious and calcareous mineral substances, as observed by the unassisted eye, and its resemblance to a similar peculiarity present in certain specimens of *Ophite* from the Grand Calumet, Canada, and which alone first gave rise to the supposition that it represented a fossil, have evidently suggested the same idea in connection with the Yellanbile rock; but diligent observation with the microscope does not bring out the least trace of anything approaching to the so-called 'canal system,' or 'nummuline layer,' diagnosed for Eozoon."

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MALLET, J., ESQ.—Professor of Applied Chemistry, University of Virginia.—A fine specimen of Meteoric Iron, from the mass found in Augusta Co. Virginia.

THEOBALD, WM., ESQ.—A collection of seventeen ancient stone implements from British Burmah.

HACKET, C. A.—A small agate implement from the Chambul valley, Kerowlie.

PEAL, S. E. G., Assam.—A supposed ancient stone implement, found in the clay near Sibsaugor, Assam.

STEWART, A. G., C. S., Rajahmundry.—A series of fossils from Kateru near Rajahmundry.

ACCESSIONS TO LIBRARY.

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Titles of Books. *Donors.*

ALBERTI, F. VON.—Beitrag zu einer Monographie des Bunten Sandsteins Muschelkalks und Keupers, (1834), 8vo., Stuttgart.

Arbeiten der Geologischen Section für Landesdurchforschung von Böhmen, (1869), 8vo., Prag.

BIANCONI, J. J.—Repertorio Italiano per la Storia Naturale. Repertorium Italicum, Vol. I, (1853), II, (1854), (1853-54), 8vo., Bononiæ.

BILLINGS, E.—Geological Survey of Canada. Catalogue of the Silurian Fossils of the Island of Anticosti, (1866), 8vo., Montreal.

GEOLOGICAL SURVEY OF CANADA.

„ Geological Survey of Canada. Palæozoic Fossils, Vol. I, (1861-65), 8vo., Montreal.

DITTO.

BOLL, ERNST.—Beitrag zur kenntniss der silurischen Cephalopoden, (1857), 8vo., Schwerin.

BRAUN, DR. C. F. W.—Beitraege zur Urgeschichte der Pflanzen.—Ueber Kirchneria, (1854), 4to., Bayreuth.

CAPELLINI, J., et HEER, O.—Les Phyllites Crétacées du Nebraska, (1867), 8vo.

DAWSON, J. W.—Geological Survey of Canada. The Fossil Plants of the Devonian and Upper Silurian Formations of Canada, (1871), 8vo., Montreal.

GEOLOGICAL SURVEY OF CANADA.

Exploration Géologique du Canada. Rapport de Progrés pour 1844 et 1853-56, 8vo., Toronto.

GEOLOGICAL SURVEY OF CANADA.

FLEMING, DR., et KONINCK, L. DE.—Mémoire sur les Fossiles Paléozoiques recueillis dans l' Inde, (1863), 8vo., Liége.

Geological Survey of Canada. Figures and descriptions of Canadian organic remains.

Decade I. SALTER, J. W.—Fossils from the base of the Trenton Group, (1859).

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„ III. BILLINGS, E.—Cystideæ and Asteriadæ.

„ „ and SALTER, J. W.—Genus Cyclocystoides.

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Titles of Books. *Donors.*

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GEOLOGICAL SURVEY OF CANADA.

Geological Survey of Canada. Report of Progress from its commencement to 1863. With Atlas, (1863), 8vo., Montreal.

GEOLOGICAL SURVEY OF CANADA.

„ „ „ Summary Report of Progress in Geological Investigations, dated 1st May 1869.

„ „ „ Summary Report of Progress in Geological Investigations, dated 1st May 1870, (1869-70,) 8vo., Ottawa.

DITTO.

„ „ „ Report of Progress for 1848-49.

„ „ „ „ „ 1852-53.

„ „ „ „ „ 1858.

„ „ „ „ „ 1866-69, 8vo., Montreal.

DITTO.

GOMES, B. A.—Commissão Geologica de Portugal Vegetaes Fosseis. Flora Fossil do Terreno Carbonifero, (1865), 4to., Lisbon.

HOSIUS, PROF. DR.—Beiträge zur Geognosie Westphalens. Die in der Westfälischen Kreideformation vorkommenden Pflanzenreste, (1869), 8vo., München.

HUNT, DR. T. STERRY, Canada.—A Geographical, Agricultural, and Mineralogical Sketch, (1865,) 8vo., Quebec.

GEOLOGICAL SURVEY OF CANADA.

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DITTO.

„ „ „ Geological Survey of Canada. Report on the Goderich Salt Region, (1870), 8vo., Montreal.

DITTO.

„ „ „ Geological Survey of Canada. Report on the Gold Region of Nova Scotia, (1868), 8vo., Ottawa.

DITTO.

LOGAN, W. E.—Remarks on the Mining Region of Lake Superior, and Report on Mining Locations claimed on the Canadian Shores of the Lake, (1847), 8vo., Montreal.

GEOLOGICAL SURVEY OF CANADA.

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MURRAY, ALEXANDER.—Report on the Geology of Newfoundland for 1865. With a Prefatory Report and an Appendix by Sir W. E. Logan, (1866), 8vo., Montreal.

GEOLOGICAL SURVEY OF CANADA.

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DITTO.

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PERIODICALS.

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" " of Science and Arts, 3rd Series, Vol. III, Nos. 13-19, (1872), 8vo., New Haven.

Annales des Mines, 7th Ser., Vol. I, liv. 2, (1872), 8vo., Paris.

L'ADMINISTR. DES MINES.

Annali di Storia Naturale, Fasc. I, (1829)—XII, (1830), 8vo., Bologna.

Annals and Magazine of Natural History, 4th Ser., Vol. IX, Nos. 54–56, (1872), 8vo., London.

COSTA, ACHILLE.—Fauna del Regno di Napoli, Fasc. 116, Neuroptera, (1860-70), 4to., Napoli.

Geological Magazine, Vol. IX, Nos. 1–8, (1872), 8vo., London.

HANLEY, SYLVANUS, and THEOBALD, WM.—Conchologia Indica, pt. 4, (1872), 4to., London.

Indian Annals of Medical Science, No. XXIX, (1872), 8vo., Calcutta.

THE EDITOR.

Indian Economist, with Agricultural Gazette and Statistical Reporter, Vol. III, Nos. 11, 12, and Vol. IV, No. 1, (1872), 4to., Bombay.

GOVERNMENT OF INDIA.

London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 4th Ser., Vol. XLIII, Nos. 288–291, (1872), 8vo., London.

MARTINI UND CHEMNITZ.—Systematisches Conchylien Cabinet, Lief. 208, (1872), 4to., Nürnberg.

Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Jahrgang, 1872, Heft 1–4, (1872), 8vo., Stuttgart.

Nuovi annali delle Scienze Naturali—

1st Ser., Vol. I, (1838)—X, (1843).

2nd " " I, (1844)—X, (1848).

3rd " " I, (1850)—X, (1854), 8vo., Bologna.

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PRINCIPAL, THOMASON COLLEGE, ROORKEE.

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DEPARTMENT OF MINES, VICTORIA.

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DITTO.

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CHIEF COMMISSIONER OF BRITISH BURMA.

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DITTO.

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TRANSACTIONS, &c.

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THE ACADEMY.

" Zeitschrift der Deutschen Geologischen Gesellschaft, Band XXIII, heft 4, (1871), 8vo., Berlin.

THE SOCIETY.

CALCUTTA.—Journal of the Agricultural and Horticultural Society of India, New Series, Vol. III, pt. 2, (1872), 8vo., Calcutta.

THE SOCIETY.

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THE SURVEY.

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DITTO.

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THE ACADEMY.

Thomsen, Julius. Thermochemiske Undersoegelser, (1871), 4to., Copenhagen.

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THE SOCIETY.

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THE SOCIETY.

„ Nachrichten von der k. Gesellschaft der Wissenschaften und der Georg-Augusts-Universität aus dem Jahre, 1871, (1871), 8vo., Göttingen.

DITTO.

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LONDON.—British Museum. Gray, J. E. Catalogue of Ruminant Mammalia (*Pecora*, Linnæus), in the British Museum, (1872), 8vo., London.

BRITISH MUSEUM.

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THE SOCIETY.

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DITTO.

„ Quarterly Journal of the Geological Society, Vol. XXVIII, pt. 2, No. 110, (1872), 8vo., London.

DITTO.

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THE INSTITUTE.

Transactions of the American Philosophical Society, New Series, Vol. XIV, pt. 3, (1871), 4to., Philadelphia.

THE SOCIETY.

Proceedings of the American Philosophical Society, Vol. XII, No. 87, (1871), 8vo., Philadelphia.

DITTO.

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Titles of Books.	*Donors.*
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VIENNA.—Jahrbuch der k. k. geologischen Reichsanstalt, Band XXI, No. 4, (1871), 8vo., Vienna.	THE INSTITUTE.
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OF

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VOL. V.

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THOMAS OLDHAM, LL.D., F.R.S.,

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RECORDS

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GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1873. [November.

NOTE ON SOME OF THE IRON DEPOSITS OF CHÁNDÁ, CENTRAL PROVINCES, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

My present contribution to the Records of the Geological Survey refers to a few only of the deposits of iron-ore found in the Chándá district, and gives some details relative to the amount of ore and fuel ordinarily used in native furnaces, showing what results are obtained without the use of foreign slag-forming ingredients.

I am indebted to Major Glasfurd, the Deputy Commissioner, for my quantitative figures; and although it is always more satisfactory to have an accumulation of data, I think the six experimental trials which are recorded yield a fair indication of the work accomplished by the method of smelting adopted in this country.

Iron-ore exists in great quantity; and as it occurs principally in the metamorphic rocks, it is found in those portions of the Chándá district which are to the north and east of the main Wardhá valley coal-field. Anhydrous hæmatite is the most abundant species, and it furnishes all the supplies for the native furnaces. It is usually compact, and is mixed up occasionally with some magnetic oxide and a little brown iron-ore.

The latter variety of hæmatite occurs often as a coating to an interior mass of anhydrous hæmatite. It presents in many instances an exceedingly beautiful appearance, having a clear smooth surface on the outside, and being finely fibrous on the transverse face. There is no difficulty in distinguishing it, for it gives a well defined brown streak on being scratched; and any person interested in possessing an illustrative mineralogical sample of iron-ore, showing the passage of one variety into the other, may obtain in the Chándá district many such specimens as that which I have described.

The most noted localities for abundance and excellence of ore are Déwalgaon, Gúnjwáhí, and Lohárá; but there are several others which run them close for a place in the first rank. The wealth of Chándá in iron-ore is undeniable. In the form either of magnetic oxide, hæmatites, carbonate, or as laterite, one is constantly meeting with it.

The deposit most worthy of notice which I have hitherto seen is undoubtedly that at Lohárá. It deserves, and will some day obtain, a more than local reputation. The ore consisting of compact crystalline hæmatite or specular iron-ore with some magnetic oxide, forms a hill fully three-eighths of a mile in length, two hundred yards in breadth, and a hundred to a hundred and twenty feet in height. The main lode striking north-east by north can be traced clearly for some distance beyond the distinctive hill portion which first catches the eye, and its actual length if followed out (but which I am sorry to say I had not time to do on the occasion of my visit) would probably exceed several miles.

The view presented by such a mass as that at Lohárá, exclusively made up of almost pure specular iron, it does not fall to the lot of many men to see surpassed; and those who possess the opportunity of visiting this place ought to do so, and carry away with them the remembrance of having looked upon one of the marvels of the Indian mineral world.

The ore at Lohárá has been analysed by Mr. David Forbes, and I extract from the Colliery Guardian* the following statement of its composition:—

Iron, metallic	69·208
Oxygen, in combination	29·376
Manganese, sesquioxide	·090
Silica	·823
Alumina	·432
Lime	·054
Magnesia	Trace.
Sulphur	·012
Phosphorus	·005
	100·000

It will be seen that it is extremely rich in iron, and exceptionally free from sulphur and phosphorus, which are usually two of the most annoying ingredients that the iron-master has to contend with. The amount of silica is less than would be presumed to exist, judging by the external appearance, compactness, and hardness of the ore.

It is not, however, to the Lohárá deposit that I wish to draw attention so much, as to some others, which—since the question of establishing large iron-works in India has been again raised—have lately acquired increased importance, due to their propinquity to a small area of *possibly* coal-bearing-rocks, about six miles west of Chimúr, which I discovered and mapped during the past season.

These deposits are three in number, and occur near the villages of Bissí, Pipalgaon, and Ratnápúr.

(1). Bissí.—Long. 79°28′ East, and Lat. 20°39′ North. The ore occurs in a lode about a mile directly east of the village, and contains hæmatite and magnetic oxide of iron.

(2). Pipalgaon.—Long. 79°34′ East, Lat. 20°32′ north. An excessively fine mass of red hæmatite, resembling that which occurs at Lohárá, and having probably the same composition, is to be seen about three quarters of a mile east of Pipalgaon. The strike of the lode is west-north-west, east-south-east.

(3). Ratnápúr.—Long. 79°37′ East, and Lat. 20°23′ North. A very rich lode of brown iron ore, forms a terrace on the north side of the small range of hills facing Alísúr. The width of the lode in places is 40 and 50 feet.

The coal rocks which I have referred to as giving increased importance to the deposits just described, occupy a somewhat restricted area. I have not been able to prove the actual existence of coal by the discovery of an outcrop; but Damúdá and Kámthí strata occur; and a very few shallow borings, not exceeding 300 feet at the utmost, sunk between Morepáh and Bandar* ought to determine the question. I do not entertain the idea that there is any present chance of profitable blast-furnaces being erected in the Chándá district. We have a long pupilage to go through before we can work successfully with such coal as has hitherto been found in the Wardhá valley field. It may, therefore, perhaps be urged that if this be the case, there is no immediate necessity for proving the ground which I have pointed out. But I am writing with the full knowledge that there is a boring establishment at Warora, and that possibly if the present opportunity of profiting by it be neglected, many years may elapse before mechanical means are again available for purposes of exploration. Should the borings which I recommend be carried out, we shall gain positive knowledge in reference to the rocks, and if there be no coal, we shall not be indulging in vain speculations regarding the utilization of the iron ore deposits to which I have drawn attention.

The native furnaces of Chándá are somewhat taller and larger than those commonly in use in Bengal. Several that I measured were nearly 6 feet in height, owing to a prolongation upwards of the front face of the furnace, the use of which is to back up the ore around the feed-hole. The height of the actual working shaft varies from 4′ 6″ to 5 feet.

The section of the furnace is that of a cone, its internal diameter diminishing from 1′6″ at a height of six inches above the hearth to three quarters of a foot at a height of 36 inches above it.

The hearth, as is usual, slopes from behind forwards, and the bloom is taken out through the face.

The twyers are 9 inches long, 1½ inches in diameter at the larger opening, and ⅝ths of an inch at the smaller. The bellows for producing the blast are usually worked by hand.

I need not refer to the method of smelting, further than to say that it is similar to the mode in use in other parts of India, and I will now give the results and details of the six experiments which Major Glasfurd undertook to have made.

Three experiments were conducted in the Múhl Tahsíl, at Chikli, Gúláb-bhúj and Metégaon; and three in the Brahmápúrí Tahsíl, at Armorí, Déwalgaon and Injhéwárá:—

Village.	Iron ore used.	Charcoal used.	Iron yielded.	Cost of iron ore and charcoal used.	Value of iron.	Wages of 2 men.
	Seers.	Seers.	Seers.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Múhl.—						
Chikli	49	82	17½	0 9 0	1 0 0	0 4 0
Gúláb-bhúj	65	88	13¼	0 9 0	0 13 0	0 4 0
Metégaon	72	90	21½	0 9 0	1 3 0	0 4 0
Bráhmápúrí.—						
Armorí	37½	68	12	0 4 6	0 9 7	0 3 2
Déwalgaon	53	114	12	0 4 6	0 8 10	0 3 2
Injhéwárá	44	88	12½	0 5 10	0 10 0	0 3 2

In these returns there is a great discrepancy in the price paid for charcoal and ore in the Mhúl and Brahmápúrí Tahsíls. Compare, for instance, Chikli (49+82 seers for 9 annas)

* Morepah: Long. 79° 21′ East; Lat. 20° 33′ North. Bandar: Long. 79° 21′ East; Lat. 20° 30′ North.

and Déwalgaon (52 + 114 seers for 4*a.* 6*p*). The yield of iron also shows great disagreement. At Déwalgaon 52 seers of ore produced only 12 seers of iron, whereas at Chikli 49 seers produced 17½. It may be that a poorer class of ore was used in the one instance than in the other, but I scarcely think this can be the case, for I have always observed that the natives invariably used ore having the same average composition. And an analysis of the Déwalgaon ore shows that it contains 70 per cent. of metallic iron.

If we calculate the proportion of the amount of charcoal used to iron ore, and the proportion of the amount of ore employed to the iron produced, we find:

Village.	Proportion of ore to charcoal.			Proportion of ore to iron.		
	Ore.		Charcoal.	Ore.		Iron.
Múhl.—						
Chikli	1	to	1·7	3	to	1
Gúláb-bhúj	1	"	1·4	5	"	1
Metégaon	1	"	1·2	3·5	"	1
Brahmápúrí.—						
Armorí	1	"	1·8	3	"	1
Déwalgaon	1	"	2·2	4·3	"	1
Injhéwárá	1	"	2·0	3·5	"	1

The iron referred to above, which is called *kít* by the Maharattas, is a mere mass of spongy iron, slag and charcoal, and has to undergo two refinings before being sold as malleable iron. In the first operation it is manipulated by the men who reduce it from its ore. They heat it in a refinery, and then hammer it, whereby the slag is more or less completely extruded and the iron consolidated into a compact bloom. It loses considerably in weight during this process, and the mass formerly weighing, say 14 seers, is diminished to 10 seers. The amount of charcoal consumed is stated to be 20 seers, or perhaps a little less. The bloom is then cut partially in half and is called *Chúl*, and is sold to the regular metal-workers (lohars). These men clean it again, by which its weight becomes still further reduced, fully one-third and sometimes one-half of it being lost; and it is by them worked up into various household and agricultural implements.

Applying the foregoing observations (by taking the mean of the Múhl figures) to arrive at the average proportions of iron-ore and charcoal used in producing iron ready for being actually worked up, it appears that—

(*a.*) Seventeen and a half seers of iron are produced from 63 seers of ore and 87 seers of charcoal.

(*b.*) In the first refining operation, 20 seers of charcoal are used, and the iron loses 5 seers in weight, reducing it to 12½ seers.

(*c.*) In the final refining operation about 10 seers of charcoal are consumed, and clean workable iron, weighing 7 to 8 seers, is obtained.

Thus, 63 seers of ore and 117 of charcoal are required by the native method of smelting as carried on in Chándá to produce 8 seers of metal. Or, stating it in current English terms—

8 Tons of ore }
and } Are used in the manufacture of 1 Ton
14½ Tons of charcoal } of wrought-iron.

There is no occasion in the present number of the Records to treat the subject of cost in its various branches, nor need I enter upon a discussion of the commercial aspect of the iron trade of Chándá. I hope to dwell at some length upon both these topics when giving a detailed description of the Wardhá valley coal-field.

For the present, I wish to draw attention to *1st*, the richness of Chándá in iron-ore; *2nd*, the circumstance of the *probable* favorable association of coal and iron-ore; *3rd*, the proportional consumption of raw materials in the manufacture of native wrought-iron. Of course, should furnaces intended either for the making of pig-iron, or for the production of wrought-iron by the direct process, be ever erected on a European scale, the data afforded by observations on the liliputian works of the natives of the country will be matter for curiosity rather than of practical interest.

CALCUTTA,
1st July 1873. } T. W. H. HUGHES.

BARREN ISLAND AND NARKONDAM, *by* V. BALL, M. A., *Geological Survey of India.*

In the month of March last, a few hours were spent on the two Islands whose names are given above by a party consisting of Mr. Hume, Dr. Stoliczka and myself. Although the time at our disposal did not admit of extended exploration, still an opportunity was afforded of checking the accuracy of the accounts which have been previously published.

Having consulted every notice of these islands which, so far as I have been able to ascertain, have hitherto been published, I have been astonished to find how inaccurate has been the information upon which the accounts in Geological Manuals and other works have been founded.

In the present paper I have devoted several pages to an abstract of these accounts, and have pointed out the errors and traced, so far as is possible, their origin.

Dr. Liebig's paper on Barren Island which contains the fullest and most accurate account of the island hitherto published, does not appear to have reached the hands of several authors who have since its publication repeated the old statements in their works.

Barren Island and Narkondam are two volcanic islands situated in the Bay of Bengal at a distance of 70 miles from one another on a north-by-east, south-by-west line. They constitute links which connect what is known as the Molucca band with the volcanic region of Arracan and Chittagong, and of which Mrs. Somerville has written as follows:—

"One of the most terribly active groups of volcanoes in the world begins with the Banda groups of islands, and extends through the Sunda groups of Trimor, Sumbawa, Bali, Java, and Sumatra, separated only by narrow channels; and altogether forming a gently curved line 2,000 miles long; but as the volcanic zone is continued through Barren Island and Narkondam in the Bay of Bengal and northward along the Coast of Arracan, the entire length of the volcanic range is a great deal more."

Dr. Hochstetter carries the line of elevations which accompanies the zone of volcanic action still further, in an oblique S. form, through New Guinea to the north of the Australian continent. "It forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie Islands being possibly considered as the extreme southern end of this curve."

So far as is known, there are no volcanoes in either the Nicobar or Andaman Islands. It has been by some supposed that the hill on Bompoka in the Nicobars and some of the high ground in the great Nicobar might be volcanic, but the evidence is rather against than in favor of this view. Plutonic rocks (diorite and gabbro) not unfrequently occur however in both islands. A statement made in an old account of the Cocos, that the little Coco is formed of volcanic rocks, is quite without foundation.

BARREN ISLAND, Lat. 12° 17′, Long. 93° 54′.

History of the island derived from previous notices.—In the table appended I have given a *précis* of all that has been published on the subject of Barren Island; but a few additional remarks tracing out the way in which certain inaccuracies have arisen seem to be desirable.

The first account was by Captain Blair, in his report on the Andaman Islands, dated 1789. I have not seen the original document, but the account was extracted and reprinted by Lieutenant Colebrooke in the Asiatic Researches. It has served for many years as the text upon which the descriptions published in various Geological Manuals have been founded.

Captain Blair gave the height of the central cone at nearly 1,800 feet, and the angle of the slope at 32° 17′. Were it not stated that the cone was equal in height to the outer walls of the surrounding part of the island, we might, in consequence of Blairs' oft proved accuracy as an observer, be disposed to believe that at the time of his observation the cone was nearly double its present height. That there has not been a general subsidence of the island to the extent of 800 feet is proved by the fact that the base of the cone was then, as it is now, but little raised above the sea level. Blair himself states that it may be seen at a distance of twelve leagues in clear weather, which would only require an elevation of about 920 feet. I can only suppose, as an explanation of the difficulty, that Blair took several heights which varied between 800 and 1,000 feet, and that these, by some error, came to be written together as 1,800.

The angle of inclination of the sides of the cone is given by Blair at 32° 17′. This nearly corresponds with the mean of my observations, which ranged between 32° and 35°. These angles also agree with those on a photograph which I possess. Dr. Liebig, Dr. Playfair and others have given it at from 40° to 45°.

The sketch by Lieutenant Wales given in Lieutenant Colebrooke's paper, save that it represents an inclination of about 60° to the sides of the cone, conveys the best idea of the island of any of the numerous figures which have been published. It was reproduced by Von Buch, and copied from him by Sir Charles Lyell, Dr. Daubeny, Dr. Buist, &c. Von Buch, in his "Memoir on the Canary Islands," gives the height of the cone at 1,690 Paris feet. His account, though apparently derived from Lieutenant Colebrooke's paper alone, contains the statement that the sea penetrates into the circle at the base of the cone. This can only have been due to some misapprehension of the meaning of Blair's words, which were as follow: "The base of the cone is the lowest part of the island and very little higher than the level of the sea."

Sir Charles Lyell, in the earlier editions of the 'Principles,' framed his account from Von Buch's. In the changes from English into French, and back again into English, the elevation of the cone became increased by 48 feet, standing in the 7th edition of the 'Principles' (1847) at 1,848 feet. It is also there stated that the circular basin inside is filled with the waters of the sea. In the 9th Edition, 1853 (I have not been able to refer to the 8th), Captain Miller's estimated elevation of 500 feet is adopted instead of the former one; but the statement regarding the sea inside still remains. In the 10th Edition (1868) Captain Miller's estimate of 500 feet, as the height in 1834, is retained; but it is stated that according to Von Liebig in 1857, both the cone and outer crater were about 1,000 feet high, and in reference to the sea we find the following: "In some of the older accounts the sea is described as entering the inner basin, but Von Liebig says it was excluded at the time of his visit." I believe this statement regarding the sea to have arisen solely in the way I have pointed out. It is important that there should be a clear representation of the case, as otherwise it might be concluded that we have evidence of the rising of the island within the historical period.

The next account to that by Blair is by Horsburgh, about which there is nothing particular to remark here, save that he asserts that in 1803 the volcano was very active (see table).

Dr. J. Adam's account is derived from information and specimens received from a friend who had landed on the island in 1832. He speaks of the stones on shore hissing and smoking, and the water bubbling all round them. The statement has apparently been understood by one writer to indicate that the lava had not then cooled down. But the hot spring was probably quite sufficient to account for the phenomena observed. This is the first mention made of the hot spring. The author supposes that the volcano is only active in the south-west monsoon, *i. e.*, requires water to bring it into a state of activity. Apart from other considerations, it is only necessary to say that the only authentic account of it in a really violent state of eruption is by Blair, who saw it on the 21st of March, and therefore not in the south-west monsoon. Captain Miller's account is very inaccurate in several respects. He has given the height at 500, and the angle at which the cone rises at 45° or even more. If the elevation of the cone in his time were only so much, then, since he states that this was also the elevation of the outer walls or amphitheatre, both must have increased *pari passu*. This view is of course untenable, and we are forced to believe that Captain Miller only gave a rough guess. His remarks on the vegetation are quite inconsistent with one another, for he says,—"there is no vegetation of any kind within the amphitheatre, but *a few small trees* are found on other parts of the island, which, however barren it may have been at one time, is *now well wooded*."

Dr. Daubeny, in his description of Barren Island, though quoting from Lieutenant Colebrooke, gives the elevation of the cone at 4,000′, which must have been due to a clerical error. A somewhat modified reproduction of the original sketch is given.

Mr. Scrope, in his work on Volcanos (*2nd Edition, Lond.*, 1862), writes regarding Barren Island: "This permanently active volcano is a cone about 4,000 feet high, rising in the centre of a circular cliff range, which entirely surrounds it except at one point where the sea has broken in." Though the authority is not given, it is evident that this account is derived from Dr. Daubeny's, as the elevation is not given at 4,000′ in any other work.

In 1846 the island appears to have been visited by the Danish corvette *Galathea*, but the only record of the fact which I know of is an inscription on a rock on the island—"*GALATHEA*, 1846."

In the *Bombay Times* for July 1852, on the authority of Dr. Buist, it is stated that the volcano was very active, but I have not been as yet able to refer to the original account.

The chief points in the accounts subsequent to the above will be found incorporated below. Dr. Playfair, Von Liebig, and the Andaman Committee agree in estimating the angle of the cone at 40° to 45°, and the elevation at from 975—980 feet.

Abstract of the published accounts of Barren Island.

	Authority.	State of Activity.	Slope of Cone.	Elevation.	Temperature of Hot Spring.	Condition of Vegetation.	References.
1787 ...	Colebrooke ..	A column of smoke arising from the summit visible 7 leagues off.	......	....	....	... ..	Asiatic Researches, Vol. IV, 1795, p. 397, fig
1789 ...	Blair ..	In a violent state of eruption, bursting out immense volumes of smoke, and frequently showers of red hot stones, weighing 3 or 4 tons	32°17′	1,800	....	Parts remote from the cone covered with withered shrubs and blasted trees.	Report on the Survey of the Andamans, and Asiatic Researches, l. c.
1791 ...	Horsburgh ..	A quantity of very white smoke close to the crater.	....	......	......	... ...	Horsburgh's India Directory, 5th Edn., Vol. II, 1843, p. 55.
1801 ...	Allan ..	... ...	...	......	...	Firewood could be got with difficulty	(Horsburgh's India Directory, as above)
1803 ...	Hötzburgh ..	Exploded regularly every 10 minutes, projecting each time a column of black smoke perpendicularly to a great height. In the night a fire of considerable size continued to burn on the east side of the crater.	......	......	... ...	...	
1832 ...	Dr. J. Adam's friend ..	Large volumes of thin white smoke continually issuing.	......	⅓ a mile=2,640 feet	Almost boiling.	Small shrubs scattered about on the S. W. side.	J. A. S. B., Vol. I, 1832, p. 128.
1836 ...	*Von Buch* .	Account same as in Asiatic Researches, with some variation.	. .	1,690 French ft	......	... ...	Description Physique des Iles Canaries, &c., Paris, 1836, p. 431, Atlas Plate VI.
1840 ...	*Sir C. Lyell** .	Account founded on Von Buch's.	.. ...	1,848	......	... ..	Principles, 6th Edn., 1840, Vol II, p. 286, also in 7th Edn.
1843 ...	Lieut. Miller .	A clear full stream of transparent vapour.	45°	Upwards of 500	... ..	No vegetation within the amphitheatre, but other parts are well wooded.	Account drawn up by Dr. McClelland, Cal. Jour. Nat. Hist., Vol. III, 1843, p. 422.

1846 ...	"Galathea" ...	... *	......	......	......	... ...	? Is there any word of this visit.
1848 ...	*Dr. Daubeny* ...	Founded on Blair's account	......	4,000 !	......	... ...	Daubeny on Volcanoes, London, 1848, p. 413.
1851 ...	*Mrs. Somerville* ...	No details ...	......	......	......	... ...	Physical Geography.
1852 ...	*Dr. Buist* ...	Quotes previous accounts ...	......	......	......	... ...	
1852 ...	"Bombay Times" ...	Very active ...	......	......	......	... ...	"Bombay Times," July 1852.
1857 ...	Dr. Liebig ...	Clouds of white vapour issued from fissures near the summit.	40°	980	104°F. ? Almost boiling.	Shrubby patches on the slopes towards the sea.	Zeitschrift der Geollog. Gesselschaft, Vol. X, 1858, p. 302; also in Rec. Govt. of India, XXV, 1859, p. 124; J. A. S. B., XXIX, 1860, p. 1; and in Mouat's Adventures and Researches.
1857 ...	Dr. Playfair and Lieut. Heathcote.	Smoke issued occasionally from a little below the summit.	40°	975	140° F. ?	Not mentioned ...	Rec. Govt. India, XXV, 1859, pp. 121—123.
1862 ...	*G. Poulett Scrope* ...	Account same as that by Dr. Daubeny.	......	4,000	......	... ...	Volcanoes, by G. P. Scroope, M. P., London, 1862, pp. 199 and 468.
1866 ...	Andaman Committee ...	A whitish vapour was evolved from several deep fissures.	40°	980	158°—163°	No trees of any height, but on the slopes and ridges are abundance of shrubs, some rising to 30 feet.	Report on Barren Island, P. A. S. B., October 1866, p. 212.

* For changes in subsequent editions, see page 82.

Authorities whose descriptions are not derived from personal observations in italics.

From the preceding we may gather the following. The volcano has probably not been in violent eruption since the years which closed the last and commenced the present century. The lava-flow which stretches from the entrance open to the sea to the base of the cone was probably poured out during this period, and raised the level of the encircling valley some 40′ above its elevation in 1789, when Blair saw it. He makes no mention of a lava stream in his time. If it did not exist then it cannot—as has been supposed by some—have been instrumental in the formation of the entrance. That this fissure was probably due to other causes we shall presently see.

From Lieutenant Wales' figure it is apparent that no material change has taken place in the general configuration, and as it has been shown that 1,800 feet cannot have been the true height, and about 920 probably was, no great alteration in the level is likely to have taken place.

General appearance of the Island.—Seen from any side but the north-west, Barren Island appears as a nearly flat-topped hill with numerous spurs running down into the sea. From some aspects, however, the top of a central cone with a column of smoke rising from it is discernible.

As the north-west side opens up to view, it is first realised that the island consists of a circular ridge forming a huge amphitheatre, which is broken down at one side for a distance of perhaps 150 yards to the level of the sea. The view obtainable through this entrance discloses a bare cone which rises from the centre of the valley. Except at a sort of shoulder not far from the top, and at two peaks close to the summit, no rocks are seen on this cone, its smooth sides being covered with grey ash and occasional strings of shingle. Towards the top some whitish patches are seen, due to the presence of gypsum mixed with the ash.

The total diameter of the island is, on the authority of Lieutenant Heathcote, 2,970 yards. The circuit of the island, from the time it took us to row round, I estimated at about six miles.

The high encircling ridge is formed of somewhat irregularly deposited layers of lava, ash and conglomerate, which dip away from the centre. A section of these may be seen on the left hand of the gap or entrance, and others at various points on the sea-face, no two of them corresponding exactly in character.

These beds or layers generally dip at angles of 35°—40°, which inclination appears to be continued steadily under the sea, as bottom, except at one place, has not been found with a line of 150 fathoms at ¼ of a mile from the shore. This steepness has been unfavourable to the formation of a fringing reef of coral of any magnitude, such as we find surrounding some of the Andaman and Nicobar groups.

The elevation of this outer ridge varies somewhat in places, but it probably nowhere is much in excess of 1,000 feet. Its highest points are towards the south and west.

The appearance presented by the inner scarped face of this amphitheatre is very peculiar. In several places cornice lines mark the position of particular beds, but a purplish grey, or in places brownish, ash spreads over the steep slopes, except towards the south-west and west, where there are some trees and shrubby vegetation. To the north, south and east a few tufts of grass—generally arranged in long vertical lines, the first being a sort of protection to those below it—are the only plants which have managed to establish a footing in the loose ash.

The outer slopes facing the sea are for the most part covered with a luxuriant vegetation, in which large forest trees may be discerned. These latter attract considerable numbers of fruit-eating pigeons (*Carpophaga bicolor*).

From its composition and character, it is evident that this ring of cliffs is the remnant of the original cone which gradually rises from below the sea. Its top and a portion of the side were, no doubt, blown off by a violent eruption, and the present cone was subsequently formed inside.

For a long time Barren Island was considered by Von Buch and others of his school as a most favourable example of his elevation theory of craters.

The gap or fissure in the surrounding walls bears about north-west-by-west from the centre of the island. It is the only place where an entrance can be obtained to the central valley.

Hot Spring.—Close to the landing place, there is a hot spring which has been mentioned in several of the accounts of the Island. Dr. Playfair found the temperature to exceed 140°, —the limit of his thermometer. Dr. Liebig's thermometer was only graduated up to 104°, but judging from the feel to the hands, he estimated it to be near the boiling point. The Andaman Committee record it at from 158° to 163°. At the time of our visit the highest temperature of the water where it bubbled out of the rocks, close to high watermark, was 130° F. We failed to boil some eggs in it which we had brought with us for the purpose.

The water is perfectly clean and sweet,* and there was no trace of sulphureous vapours. Strange to say, where, though mingled with the sea, it was still too hot for the hand to be retained in it with comfort, there were a number of brilliantly colored fish swimming about.

Facing the landing place is the termination of a flow of lava which extends backwards from this for about a mile to the base of the cone, round which it laps for perhaps ¾ of the circumference. The height or thickness of this flow of lava is about 10 feet at first, gradually rising to 50 feet where it emerges from the base of the cone. The upper surface is deeply cleft and covered over with blocks of black cellular lava which rest upon one another in confused piles. Sometimes they are poised so insecurely on one another that it is a matter of some risk to attempt scrambling over them. Towards the base of the flow the rock from its slower cooling is more compact and less cellular. In places it contains white crystals of a mineral resembling leucite. In others it is a true basalt with numerous crystals of olivine.

As pointed out by Dr. Leibig, the older lava seen in the section of the ridge differs from this; it consists of a reddish matrix with crystals of felspar (probably sanidine), olivine, and augite. A somewhat similar rock occurs on Narkondam.

On our way to the central cone from the landing place we at first endeavoured to avoid the rough surface of the lava-flow by keeping on the slope of the gap; but after a short distance the bushes and unevenness of the ground compelled us to strike down on the lava, when we found, to our astonishment, a sort of path which must have been made by the committee sent from Port Blair to report upon the grass.

Arrived at the foot of the cone, we commenced the ascent from the west. The loose ashes and shingle rendered it somewhat toilsome work; and those in front found it difficult to avoid loosening fragments of lava which bounded down the hill in a most unpleasant way for those who were following.

Dr. Liebig appears to have ascended from the north side, where it seems to have been equally difficult.

About ¼ of the way from the top there is a shoulder of rock which shows very well in the photograph. This probably marks the position of an old vent. There is a good deal of firm ground about it.

The summit of the cone is truncated, and contains an oval-shaped depression, one-half of which is partly filled with débris, and the other, some 20 yards in diameter and 50 feet

* The Andaman Committee do not appear to have realised this fact, as they spent no little time and trouble in excavating a well without finding a trace of water.

deep, has a circular bottom, which is filled with sand. This appears to have been the last crater formed on the island.

The two principal edges of the depression strike to north-west, south-east; they consist of ash permeated with fibrous gypsum (selenite); numerous cracks and fissures occur in this part of the hill, and the ground is hot. On turning over the surface, the sides of these cracks are found to be encrusted with sulphur, resting upon the rugosities of which small detached crystals of the same mineral were not uncommon. From the highest point on the northern edge a thin column of white vapour and sulphureous fumes is slowly poured forth. Even when standing in its midst, the fumes did not prove so irritating a might have been expected.

On the southern side of the crater there is some solid lava *in situ*, and on the west there is a peculiarly shaped mass which forms a conspicuous object from below. Some of the lava here has a reddish matrix and is somewhat vesicular. I also found some basalt, the outer surface of which was weathered into a white crust.

It seems probable that the nucleus of the cone is solid rock to a considerable extent, the ashes seen at the surface being only superficial.

By following water channels when they were to be found, and glissading over the ashes, the return to the base of the cone was effected speedily and without much difficulty.

By a small watch-aneroid supplied with a Vernier scale for feet, the height of the cone is 950 feet; but as one heavy storm of rain had passed, and clouds portended another, I am willing to believe that owing to the atmospheric disturbance the observation was not trustworthy, and that from 975 to 980 feet given by Lieutenant Heathcote, Dr. Liebig and others is the true elevation. The temperature on the top was 83°.

The diameter of the base of the cone is 2,170 feet according to Lieutenant Heathcote. The slopes of the cone incline, according to my observation, at angles varying between 30° and 35°. Blair gave it at 32° 17′, or about the mean of these two. Other observers say 40° to 45°, but the photograph of the cone shows that the former is correct.

Dr. Liebig has discussed the question of the amount of sulphur obtainable on the island. He seems to think the chances of finding a permanent supply very doubtful, but recommends a preliminary trial.

Considering the great expense which keeping up constant communication with the Andamans and the superintendence of convict labour would involve, I cannot see that there is any prospect of the collection and refining of the sulphur being made to pay.

So far as is known, the substance occurs only at the summit of the cone, though, doubtless, if the right places could be found, it does also occur lower down. But in such places, it could only be as an old deposit which, on being worked out, would not be replaced again.

On the summit the deposit, so far as I could see, proceeds very slowly, certainly not with sufficient rapidity to keep laborers constantly employed.

NARKONDAM, Lat. 13° 24′; Long. 94° 12′.

History and previous notices.—So little has been published regarding this island that a few lines will suffice to dispose of all that has ever been recorded regarding it.

In 1795 it was passed by Colonel Symes* when on his voyage to Rangoon, whence he started on his embassy to Ava. He speaks of it as "a barren rock rising abruptly out of the sea and seemingly destitute of vegetation."

* Embassy to Ava, Vol. I, 1827, p. 167.

Dr. McClelland, writing in 1838,* says: "It is a volcanic cone raised to the height of 7,800 feet. He gives a sketch showing the figure of the cone, the upper part of which is quite naked, presenting lines such as were doubtless formed by lava currents descending from the crater to the base, which last is covered with vegetation." No soundings are to be found at the distance of half a mile from the shore. This account is reproduced by Mrs. Somerville, Dr. Daubeny, Dr. Buist and Mr. Scrope.

Horsburgh† says—Narkondam may be seen about 14 or 15 leagues from the deck, and appears in the form of a cone or pyramid with its summit broken off; it is bold and safe to approach all round.

Mr. S. Kurz, in his report on the vegetation of the Andaman Islands, writes: "Narkondam Island has an extinct volcano remarkable for the great height of its cone, being twice as high as its outer wall. Owing to the great height of the cone (perhaps 2,000 feet) in proportion to the surrounding wall, this island must have sunk very much, or the volcano must have been formed from a considerable depth in the sea." Mr. Kurz gives an outline sketch of the island as it appeared to him from a distance of 20 miles.

In a paper on the geology of the neighbourhood of Port Blair, I made a few remarks on the appearance of Narkondam as seen from a few miles distance. In it I accepted the height of the cone, 2,150, given on the chart, as authentic. This, it will be seen by the sequel, I do not now adopt as correct. In the *Indian Observer* for the 10th of May a short account of the present visit will be found.

Viewed from the north-west at a distance of about 4 or 5 miles the island of Narkondam appears to consist of a tolerably regular cone which rises from an interrupted ring of irregularly piled masses. The apex is somewhat truncated, but has three distinct peaks. On the occasion in 1869 when I first saw the island a dense mass of cloud rested on the top, and I was unable to make out the character of the summit. But when subsequently seen, it was observed that there were three peaks as represented in the sketches published by Mr. Kurz and Dr. McClelland. The upper parts of the cone and the sides for more than half way down are deeply furrowed by ravines, and what appears to be a low scrub jungle spreads uniformly over the island save upon some vertical scarped faces.

With the general consent of those who have seen it, the conical form has been accepted as a proof of the volcanic character of the island. Dr. McClelland, as noted above, speaks of the lined appearance being "doubtless formed by lava currents descending from the crater to the base." These lines are, however, simply the result of erosion, and mark the position of the watercourses.

The elevation of the summit of the cone has been variously estimated at from 700 to 2,150 feet. Since however, according to Horsburgh, the island first becomes visible from the deck of a steamer at a distance of from 14 to 15 leagues; it is probable that about 1,300 feet would be nearer the true altitude, and such indeed, judging by the eye, appears to be a very fair estimate.

On the occasion of our visit we landed in a small bay on the north-west side of the island. At about 100 yards distance from the beach the water became so shoal that we were compelled to land on a raft. We soon found that the jungle which, in the distant view, appeared to consist mainly of low scrub was really composed of large forest trees with a thick undergrowth. So dense was this, just above high water mark, that at first it seemed probable that it would be impossible to penetrate it. Added to the natural density of the jungle, another obstacle was presented by the prostrate condition of many of the trees, which in their fall had carried

* On the difference of level in Indian Coal-fields, J. A. S. B. VII. Also in the Coal Committee's report, and in Corbyn's Indian Review.

† Indian Directory, 5th Ed., Vol. II, 1843, p. 55.

down tangled masses of creepers and the lower vegetation. It soon became apparent that at no very distant period a violent hurricane or cyclone must have swept across the island. An entrance was at last found, and for three hours, cutting our way and making constant detours to avoid fallen trees, we endeavoured to force onwards to the summit, but were at length compelled to give up all hope of succeeding and returned to the beach. Further evidence of the hurricane was there afforded by numerous fragments of a wreck which had been thrown up on the sand. Subsequently this storm was identified with one which took place on the 26th of October 1872, and did much damage in the Cocos Islands and other parts of the Bay.

The only rock seen where we landed was a conglomerate, or boulder bed some 50 feet thick. The boulders consisted of a trachytic porphyry which contained sanidine, augite, and mica in grey or pinkish matrices. We discovered no evidence whatever of recent lava or basalt occurring, though either or both may exist, as our observations were confined to one small bay.

Notwithstanding the luxuriance of the jungle which included species of Ficus, Palms (Caryota), Acasia, Calosanthes, &c., no fresh water was discovered.

Much remains to be done in the exploration of this most interesting volcanic island. It is particularly desirable to ascertain whether there is really a crater at the summit, and whether there are any traces of recent lavas.

Future visitors would do well to provide themselves with some wood-cutters. They should land near the northern spur, and getting then on the steady rise, they will probably find no insuperable obstacle on their way up.

STRAY NOTES ON THE METALLIFEROUS RESOURCES OF BRITISH BURMAH, *by* W. THEOBALD, *Geological Survey of India.*

Though little that can, strictly speaking, be called precise information respecting the mineral wealth of Burmah exists, either as regards the value or extent of its presumed mineral sites, yet it may be not without interest to give a brief sketch of what stands recorded on the subject, leaving for future investigators the task of sifting these statements and determining the importance in an economic point of view of each separate locality.

A general impression is undoubtedly prevalent that considerable metalliferous resources exist in Martaban and Tenasserim, and that it only requires a thorough examination of these districts to establish the fact in a manner sufficiently clear and precise to tempt the European speculator and capitalist into the field, and originate a new and thriving branch of industry which would soon prove of great value to the province. Unfortunately, nothing very tangible is known, though the matter has never been quite lost sight of, and has attracted the attention of district officers, among whom Mr. O'Riley in Martaban, and Major Malcolm Lloyd in Tounghoo, may be prominently mentioned. A serious cause, however, of error, and of a too favourable view being taken of the productiveness of a new mineral locality, lies in the fact that undue importance is too commonly attached to the result of an analysis of a small specimen, which in reality affords no criterion whatever of the value of the discovery in an economic point of view, since the actual richness of the ore is perhaps the least important element to be considered; the two far more important points for consideration being the amount of ore procurable, and its position as regards water carriage, and other facilities for its extraction and reduction. Of course, all other conditions being equal, a rich ore is more valuable than a poor one; but the mere analysis of a small specimen of ore, how rich soever it prove, is no criterion whatever of its economic value, or whether it can be profitably worked. A reduced copy of Mr. O'Riley's map of Martaban, showing mineral sites, is published herewith for general convenience.

The only ores which need be noticed for practical purposes are those of iron, tin, lead, copper, antimony, none of which, save iron, are known to occur West of the Sittoung, but are confined to the belt of country running up from the British boundary on the Pakchan creek in Latitude 10° North to the frontier in Latitude 19° 30'. This tract of country differs essentially from the ground West of the Sittoung, the former being composed of several groups of beds of Palæozoic age, both altered and unaltered, together with metamorphic rocks seemingly azoic, the whole being traversed by granite and elvan dykes and pierced by numerous hot springs, whilst the latter is wholly made up of Secondary and Tertiary rocks, the newer greatly predominating; and wherein intrusive rocks are next to unknown. Physically also, and as regards climate, the country East of the Sittoung differs no less from that West of the river, than it does geologically. Martaban is essentially a mountainous country with lofty chains stretching in a north-north-west direction, some of whose peaks rise to 6,000 or 8,000 feet, and would afford some of the most charming sanitaria in India were they only a little more accessible to those who might be benefited by a resort to them. As a result of the geological constitution of the ground, copious and perennial springs abound and give rise to a charming verdure and coolness even over the lower elevations to which I know of no parallel elsewhere; and though said to be unhealthy (how truly I know not), the pine forests of the Youzalin are among the coolest and pleasantest districts, as far as temperature goes, which India can offer. It is this very district which, according to common report, teems with mineral wealth; but a most unfortunate drawback to its proper investigation is its wildness and want of population, which means also want of roads of any sort, and difficulty in the matter of supplies, not to allude to risk of sickness (a common concomitant, among camp-followers at least, on a greatly reduced temperature), and the attack of plundering bands, which find a sort of happy hunting ground along all this difficult wild country adjoining on the Karen-ni and Zimmay territories; traders and travellers being the special victims of these freebooters. The regular dacoit, moreover, is not the only 'conveyancer' to be dreaded; as it was but little more than a year ago that the entire police guard escorting some treasure, belonging to a trader, appropriated the money and then humourously stepped across the frontier with their arms, accoutrements and all as they stood, heedless of the feelings of disappointment, if not shame, which their doing so must have caused their comrades whom they left behind.

Iron.—Excellent ores of this metal occur both in Pegu, Martaban and Tenasserim, and in former days were smelted by the Burmese, but the manufacture is no longer to my knowledge carried on in British Burmah, though iron is still made in Upper Burmah, near Puppadoung, from ores similar to that formerly used in the Prome district. In Pegu (Eastern Prome) the ore occurs in the form of concretions of an earthy hydrated peroxide disseminated through the newer Tertiary beds which are there so extensively developed, and of which an account is given in the Records of the Geological Survey of India for 1869, page 83. East of the Sittoung the ore usually met with is the magnetic, a mixture of the protoxide and peroxide, often occurring in thick beds or lodes, and a valuable ore for smelting. Specular iron also occurs as an integral constituent mineral in some of the crystalline schists, and has from its brilliancy been mistaken for galena.

Mr. O'Riley remarks that "iron occurs abundantly in the lower ranges of the hills to the east of this station" (Shuay Ghyin), and the same valuable ore, the magnetic oxide, is known also to occur in Tavoy; but these deposits will probably not prove remunerative to work for many years, or till the difficulties which of late have threatened mining industry in England shall have become more weighty and confirmed.

Tin.—This metal is unquestionably the most important commercially of any produced within our Eastern possessions. Though beyond some workings near Malee-wan on the Pakchan river, near Latitude 10° 10' North, the ore is nowhere systematically worked on a large scale within British territory. South of the Pakchan stream the richness of the tin washings derived from the degradation of a stanniferous granite, in which the tinstone occurs as one of the integral constituents of the rock, is well known, and reference may be made for information connected with this question to a report of Dr. Oldham, published in Selections from the Records of the Government of India, No. 10, page 56.

But the fact of most interest as regards British Burmah is, that this stanniferous granite and its associated deposits of stanniferous gravel, stretches up as far north as the parallel of Tounghoo, east of which station on the eastern slopes of the Pounglong Range, the metal has from time immemorial been worked by the Karen-ni, or Red Karen tribes within whose territory it lies. Tin ore has long been known to occur in the streams discharging into the Henzai basin in Latitude 14° 40′ and also at "Chando near Palouk, about two days journey from the sea, halfway between Mergui and Tavoy" (*vide* Gleanings of Science, vol. I, page 143); but how far to the north of Tounghoo this stanniferous granite continues, is not known, though as likely as not for 500 miles or more. As the tin works above alluded to at Kamapew, are some 2 miles beyond British territory, it is very important that Mr. O'Riley has traced the ore across the range of hills into the drainage basin of the Sittoung; and to Mr. O'Riley belongs the credit of having first drawn attention to the above fact. His words are as follow: "Tin: of the existence of this metal within the area of this district, I was convinced from having traced the stanniferous formations of the "Kaimapyu" which fall into the Salween, across the ranges of hills, whose drainage flows into the Sittang valley, and on forwarding to the Karens specimens and instructions, I was enabled to procure the specimens A. B." Of course Mr. O'Riley may have been misinformed, and the specimens in question may in reality have come from the Eastern, Salween valley, side of the hills and not from the British or Sittoung side; but as Mr. O'Riley was fully aware of the importance of this point, I am prepared to believe his statement in this particular to be correct. Mr. O'Riley goes on to add: "The specimen A exists in the hills north of the Youkthwah river, within the Tounghoo district, and the other, in the head waters of the main stream." I myself received some corroborative testimony to the same effect, when examining some hot springs in the lower part of the Youkthwah river; but nothing is actually known of the precise locality where the ore exists, nor can be till some one is specially deputed to examine the question. Major Malcolm Lloyd, Deputy Commissioner of Tounghoo, has much interested himself with the resources of his district, and has furnished me with the following itinary from Tounghoo to Kay-mah-pew, from which the difficult nature of the intervening country may be inferred, since the actual distance from Tounghoo is probably not much over 45 miles. On the last march the British boundary is crossed about the fourth mile.

Route from Tounghoo to Kay-mah-pew.

	Miles.
Tounghoo to Khoung-nouk-kwa	18
Khoung-nouk-kwa to Paylawa	8
Paylawa to Bogallee	8
Bogallee to Nothedoe	10
Nothedoe to Mobwaydo	10
Mobwaydo to Ivoobo	6
Ivoobo to Kadowboe	16
Kadowboe to Kay-mah-pew	15
	91

The current price of tin ore in Tounghoo used not to exceed, as I am informed by W. Usher, Esq., Rs. 185 the hundred viss (about 375 lbs.); but latterly the price has risen to Rs. 205 and even to Rs. 230 for choice lots, the same realizing Rs. 250 in Rangoon. As the carriage from the mines to Tounghoo is at present wholly by coolies, it seems desirable to ascertain if no alternative route can be devised by the Salween to Moulmein, making use of water carriage for part of the way.

GALENA.—This ore is known to exist in numerous spots in Martaban and Tenasserim, and is usually argentiferous to the extent on an average of 12 ounces of silver per ton of lead, taking as a guide the first six analyses of the subjoined table. In this respect the galena from Bamo and Upper Burmah is far richer, the mean of three samples from Bamo, giving 78 oz. 17 dwts. of silver to the ton of lead, the poorest yielding 58, and the richest 104 ozs.

Table exhibiting the amount of silver in ounces per ton of lead, from samples of Galena from various parts of Burmah.

			oz.	dwts.	gr.
1.	Galena	Martaban	5	8	0
2.	Do.	do.	5	14	0
3.	Do.	do.	9	0	0
4.	Do.	Tavoy	16	7	19
5.	Do.	Moulmein	19	5	14
6.	Do.	Tounghoo	20	8	7
7.	Do.	Bamo	58	14	8
8.	Do.	Bamo (Ponsee)	73	10	0
9.	Do.	Bamo (Kyet-yo)	104	10	16

Nine localities where galena occurs are marked in the sketch map of Martaban by Mr. O'Riley, ranged generally on a north-north-west line of bearing, coinciding with the general direction of the hill ranges, and extending over a line of country some 90 miles in length. Mr. O'Riley describes the ore as occurring in the mountain-limestone formation of the district, which is that also to which the magnificent and picturesque limestone hills near Moulmein, and along the Salween belong, but he does not say if the ore occurs disseminated in the rock, or in the form of a true mineral vein or lode. From what I have remarked on the north-east of Tounghoo, at the spot whence Major Lloyd procured his galena, I am inclined to think that it may occur on both ways, as it is there rather doubtful if there is a true vein, whilst on the Salween valley, the accounts would certainly suggest the existence of lodes.

I am sorry I cannot give any account of the attempts which have been made by private parties to work the lead and silver of Martaban, but much reticence is naturally observed on such a subject, either from a feeling of distrust or of vexation at the unfortunate results of crude attempts and hasty speculation. Nothing that has as yet been done, however, can be considered as conclusive either for or against the practicability of bringing these ores into the market. At present the wild state of the country seems to me the main obstacle to arriving at a satisfactory conclusion on this subject, from the sparseness of population and consequent inability for any one to properly scrutinize these impenetrably clad hills.

COPPER.—Four specimens of copper ore were procured by M. O'Riley, three of them from the same localities as the galena, one of them from the hills east of the Sittoung River, and all consisting of "the ordinary copper pyrites, both arsenical and combined with sulphur and iron." I have not myself been so fortunate as to procure any undoubtedly Martaban copper ore, save pieces brought to me exhibiting traces of that metal in the form of green carbonate associated with iron or lead ore, to the extent, and no more, of implying the presence of a small portion of the more valuable metal in the mass. Not far from Moulmein on the Ataran River, I have seen heaps of slag which some believed to be old copper workings; but an analysis shows that the slag does not contain so much as a trace of copper, and indicates merely the former presence of iron works, abandoned before the memory of the existing inhabitants.

An extremely interesting specimen of copper ore of a somewhat novel composition was procured by M. O'Riley from some spot on the Yoonzalin River, said to be accessible for boats.

Mr. Waldie, who analysed it, describes it as a new mineral species under the name O'Rileyite, in the Proceedings of the Asiatic Society of Bengal for 1870, page 279. Two analyses of the samples were made as below, the first being that of a sample forwarded on the 24th July, the second, which differs slightly, a sample forwarded subsequently:—

Copper	17·000
Silver	0·096
Iron	36·470
Antimony	1·150
Arsenic	32·700
Sulphur	1·860
Earthy matter	0·560
Deficiency and loss	10·664
	100·00

The silver in the above sample is equal to 31½ ounces troy per ton. The large amount of loss, however, (presumed to be mainly arsenic) was unsatisfactory, and Mr. Waldie, therefore, made a careful analysis of a second sample of the same mineral, forwarded by M. O'Riley on the 10th of October, with the following results:—

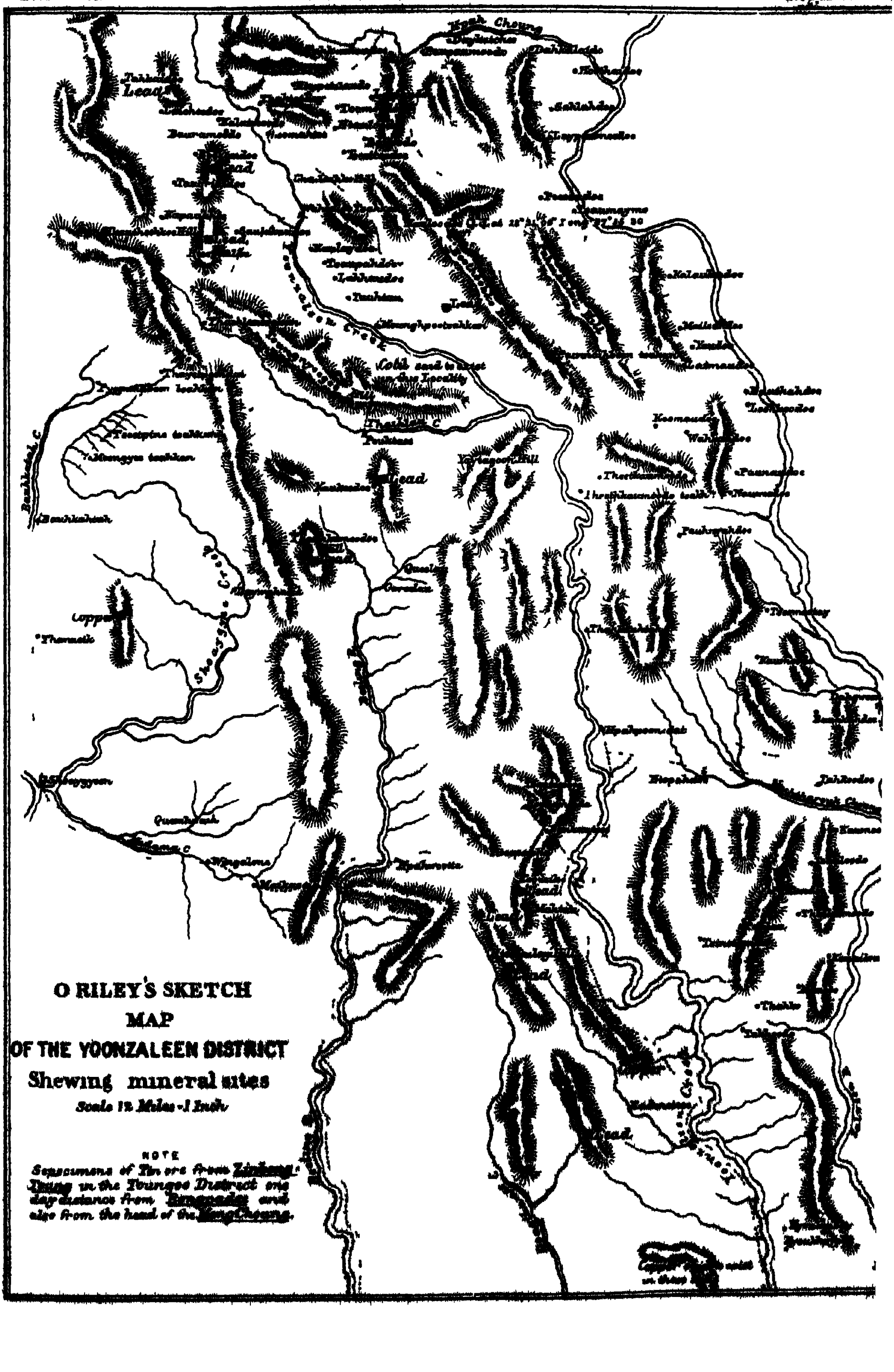
Specific gravity: In small pieces 7·348: In powder 7·428.

Copper	12·13	
Iron	42·12	
Arsenic	38·45	
Antimony	0·54	
Earthy matter	0·12	
Oxide of copper	1·21	Soluble in dilute hydrochloric acid.
" lead	1·89	
Arsenious acid	1·12	
Protoxide iron	1·97	
Loss	0·45	
	100·00	

Indications of the presence of copper, in the shape of stains of the green carbonate, are also occasionally met with; one such being recorded in the Geological Notes by Captain W. Foley, in the *Botoung* hills, 90 miles north-north-east from Moulmein (Maulamgeng); his words are: "Silver ore is said to exist in a limestone rock at this place; and judging from the numerous excavations that had been made by those in pursuit of the precious metal, no little labour has been used in the endeavour to discover it. I had neither time nor opportunity for ascertaining whether silver ore *does* so exist. Pieces of *copper green, iron pyrites,* and *lead ore* deemed useless and cast aside by those in pursuit of silver were strewed about the place, and for the first time, in this part of the world, I observed *anthracite* dispersed in thin seams through the limestone rock."

From this interesting passage, I should infer that extensive diggings for galena had been made here, as in a note the rejected lead ore is said to be the "*arseniate,*" possibly identical with phosphate of lead containing arsenic, which has recently been received in the laboratory of the Geological Survey for analysis from the Martaban district.

ANTIMONY.—Antimony occurs associated with galena in Martaban, but is nowhere worked in British territory. Metallic antimony, however, is imported to a small extent from the Shan States, and is probably used as an ingredient in the alloys of copper and silver which are worked up for ornaments by the Shans, who excel in all sorts of metal work. Antimony does not seem to receive much attention as a metal, though the powdered sulphide is largely used throughout the East as a collyrium under the name of *soormah,* the application of which along the eyelid, in the shape of a fine black powder, is supposed to enlarge the


O RILEY'S SKETCH
MAP
OF THE YOONZALEEN DISTRICT
Shewing mineral sites
Scale 12 Miles - 1 Inch
NOTE
Sepscimens of Tin ore from Zinkang Taung in the Toungoo District one day distance from Bingmadee and also from the head of the Kengcheung.
Lead
Copper
Gold

apparent size of the eye and add to its lustre and beauty. In India at least, however, no discrimination seems to be made between the sulphide of antimony and ordinary galena, which goes also by the name of *soormah*.

GOLD.—Though of slight economic importance, gold occurs in most parts of Burmah, but is very little worked within British territory, which I attribute to the higher and more certain remuneration there obtainable for agricultural or other labor; and gold working is, therefore, pursued mainly in bad seasons, or as an exceptional means of industry taken up merely now and again.

I am not aware of platina having been discovered in British Burmah, but as it is known in Upper Burmah under the name of Shwaybeen (white gold), it probably, I think, will be found in Pegu also, but perhaps in too fine a state of division to be independently separated.

In Volume III of the Gleanings of Science a very interesting analysis of a platina 'button' from Ava is given by J. Prinsep, which I here transcribe in proof of the actual occurrence of the metal, which might also be doubted:—

Platina	25
Gold	5
Iridium and osmium	40
Iron	10
Arsenic and lead	20
	100

The sole use the metal is put to is as an alloy, the only form of course in which the Burmese are capable of manipulating it. The proportion of the metals iridium and osmium is remarkable; and additional samples from Bamo are much wanted for analysis, but such are scarcely procurable save on the spot.

An impure earthy cobalt containing manganese was many years since procured by myself near Henzai, but I could learn no particulars beyond the above rather vague one of locality. It was a nodular mass of a black color enveloped in white clay, not more than an ounce in weight altogether.

The above remarks are all that I need offer on the subject, my intention being solely to point out in a brief manner what previous observers have recorded on the subject of the metalliferous wealth of Burmah.

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PARIS.—Mémoires de la Société Géologique de France, 2nd Series, Vol. IV, Nos. 1—3, (1869—1872), 4to., Paris.

THE SOCIETY.

„ Bulletin de la Société Géologique de France, 2nd Series, Vol. XXVIII, Nos. 3—5, XXIX, Nos. 1—3, (1871—72), 8vo., Paris.

DITTO.

PHILADELPHIA.—Journal of the Franklin Institute, 3rd Series, Vol. LXIV, Nos. 4—6, Vol. LXV, Nos. 1—4, (1872—1873), 8vo., Philadelphia.

THE INSTITUTE.

„ Proceedings of the Academy of Natural Sciences of Philadelphia, Parts 1—3, (1871), 8vo., Philadelphia.

THE ACADEMY.

ST. PAUL.—Annual Report of the Board of Regents of the University of Minnesota for the fiscal year ending November 30th, 1872, (1873), 8vo., St. Paul.

GOVERNMENT OF MINNESOTA.

STOCKHOLM.—Kongliga Svenska Vetenskaps—Akademiens Handlingar, New Series, Vol. VII, heft 2, and Vols. VIII—IX, (1868—1870), 4to., Stockholm.

ROYAL ACADEMY OF SCIENCE, STOCKHOLM.

„ Lefnadsteckningar öfver kongl. Svenska Vetenskaps-Akademiens, Band I, heft 2, (1870), 8vo., Stockholm.

DITTO.

„ Meteorologiska sakttagelser i Sverige, Band IX—XI, (1867—1869), 4to., Stockholm.

DITTO.

„ Minnesteckning öfver erik Gustaf Geijer af F. F. Carlson, (1870), 8vo., Stockholm.

DITTO.

„ Ofversigt af kongl. Vetenskaps—Akademiens Förhandlingar, Vols. XXVI—XXVII, (1870-71), 8vo., Stockholm.

DITTO.

„ Sveriges Geologiska Undersokning, Nos. 42—45. With 4 maps, (1871), 8vo., Stockholm.

BUREAU RECHER. GEOL. SUEDE.

ST. PETERSBURGH.—Bulletin de l'Académie Impériale des Sciences de St. Petersburgh, Tome XVI, Nos. 1—6, XVII. Nos. 1—3, (1871), 4to., St. Petersburgh.

IMPERIAL ACADEMY OF SCIENCES.

Mémoires de l'Académie Impériale des Sciences de St. Petersburgh, 7th Ser., Vol. XVII, Nos. 1—12, XVIII, Nos. 1—7, (1871-72), 4to., St. Petersburgh.

DITTO.

Titles of Books. *Donors.*

ST. PETERSBURGH.—Beiträge zur Kenntni[illegible] [illegible]ssischen Reiches und der angrenzenden Länder Asiens, with [illegible]s, Band I, (1839), to XXVI, (1871), (1839-71), 8vo., St. Petersburgh.

IMPERIAL ACADEMY OF SCIENCES.

TORINO.—Atti della R. Accademia delle Scienze di Torino, Vol. VII, Nos, 1—7, (1872), 8vo., Torino.

ROYAL ACAD. OF SCIENCE, TURIN.

„ Bollettino Meteorologico ed Astronomico del Regio. Osservatorio dell' Universita di Torino. Anno VI, (1872), oblong 4to., Torino.

DITTO.

VIENNA.—Jahrbuch der kais. könig. Geologischen Reichsanstalt, Band XXII, Nos. 3—4, and General Register, Bände XI—XX, (1872), 8vo., Vienna.

THE VIENNA INSTITUTE.

„ Verhandlungen der kais. konig. Geologischen Reichsanstalt, Nos. 11—18, (1872), 8vo., Vienna.

DITTO.

„ Denkschriften der kais. Akademie der Wissenschaften, Band XXXI—XXXII, (1872), 4to., Vienna.

THE VIENNA ACADEMY.

„ Sitzungsberichte der kais. Akademie der Wissenschaften—
Band LXII, Abth. I, heft 3—4, Abth. II, 4—5.
„ LXIII, Abth. I, heft 1—5, Abth. II, heft 1—5.
„ LXIV, Abth. I, heft 1—5, Abth. II, heft 1—5.
„ LXV, Abth. I, heft 1—5, Abth. II, 1—5, Abth. III, heft 1—5.
With Register LXI—LXIV, (1870—1872), 8vo., Vienna.

DITTO.

WASHINGTON.—HAYDEN, F. V.—Preliminary Report of the United States Geological Survey of Montana and portions of adjacent territories, (1872), 8vo., Washington.

F. V. HAYDEN, U. S. GEOLOGICAL SURVEY.

„ HAYDEN, F. V.—Final Report of the United States Geological Survey of Nebraska, (1872), 8vo., Washington.

DITTO.

„ HAYDEN, F. V.—Supplement to the fifth annual report of the United States Geological Survey of the territories for 1871, (1872), 8vo., Washington.

DITTO.

„ THOMAS, PROF. C.—Lists of elevations and distances in that portion of the U. S. west of the Mississippi River, (1872,) 8vo., Washington.

DITTO.

WELLINGTON.—HECTOR JAMES.—Phormium Tenax as a fibrous plant, (1872), 8vo., Wellington.

THE GEOLOGICAL SURVEY OF NEW ZEALAND.

Titles of Books.

WELLINGTON.—HUTTON, F. W.—Catalogue de [illegible] (1873), 8vo [illegible]
[illegible] ZEALAND.

Transactions and Proceedings of [illegible] Vol. V., (1873), 8vo., Wellington.
THE INSTITUTE.

YOKOHAMA.—Mittheilungen der Deutschen Gesellschaft für [illegible]tur und Völkerkunde Ostasiens, Heft., 1 Mai, (1873), flsc., Yokohama.
THE SOCIETY.

ZÜRICH.—Neujahrsblatt von der Naturforschenden Gesellschaft, Nos. 73—74, (1871-72), 4to., Zürich.
NATURAL HISTORY SOCIETY, ZÜRICH.

Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, Jahrg. XV, heft 1—4 and XVI, heft 1—4, (1870-71), 8vo., Zürich.
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OF

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UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

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THE AURIFEROUS ROCKS OF THE DAMBAL HILLS, DHARWAR DISTRICT, *by* R. B. FOOTE, F. G. S., *Geological Survey of India*

It had long been known that the sands of various streams taking their rise in the Dambal Hills contain gold; but the sources from which this stream-gold was derived were not positively determined, and it was with the object of settling this point that I was officially deputed to visit the hills in question at the close of last field-season.

The results of my examination of that region show that one source of the gold is to be found in at least one auriferous quartz reef, which will be described further on.

Stream-gold is known to occur also in several other places in Dharwar and Belgaum Districts, but, as far as I could ascertain, in very much smaller quantities. One locality in the Kuladgee District is doubtfully reported as auriferous. These occurrences will be again referred to.

Geographical position

The Dambal Hills are situated in the Gudduck Talook, some miles south-south-east of the town of Gudduck, and are locally known as the Kappatgode, being so called after the temple sacred to Kappat Iswara, which stands on the western flank of the main hill, in long. 75° 45′ east, and lat. 15° 13′ north. They form the northern part of a belt of elevated ground extending in a single or double ridge north-north-west from Harpunhully, in Bellary District, across the Toongabadra to Bingud Kuttee, 3 miles west of Gudduck, where the ridge sinks into the great, black, regur-covered plain of Dharwar. The Kappatgode itself forms the highest part of the ridge, which there rises about 1,000 feet over the surrounding country in a bold, steep mass, whose flanks, though bare of jungle, are much obscured by débris, and during the rains well covered with long lemon-grass.

Rocks belong to the gneissic series.

The rocks which form this ridge and all the adjacent country for many miles around belong to the great gneiss formation of Southern India, and have here been subjected to immense disturbances, producing great contortions and fractures, and in parts a much greater degree of metamorphism than is usually met with, which adds greatly to the difficulty of unravelling the very obscure stratigraphical features of these hills. A complete solution of these stratigraphical obscurities will only be obtained by extending the survey both north and south of the auriferous tract, to which alone I confined my attention, as my time was limited and moreover much encroached upon by frequent heavy rain-storms. Immediately north of the Kappatgode Hills the continuity of the ridge is broken by a cross valley running nearly due east and west, and opening into the plains immediately west of Dambal. This valley is drained by the Dhoni nullah, which falls into the great Dambal tank, whence its waters eventually drain into the Toongabadra. On the south side of this valley the hills widen out considerably owing to the presence of a third ridge, but contract again to the south of the Kappatgode.

Geological structure of the ridge.

The ridge in its northern part, lying beyond the gold tract (where it is single and its structure quite simple) shows a double series of hæmatite schist beds intercalated between chloritic and other schists of great thickness, which to the east touches a broad band of highly silicious and often granitoid gneiss, on which stands the town of Gudduck. I found no section showing the exact relations of these two series; but it is most probable that the granitoid series, which may conveniently be called the Gudduck series, overlies the chloritic and ferruginous beds. On reference to the map accompanying these notes, it will be seen that further south a third hæmatite schist band appears at a still lower level, also accompanied by chloritic, hornblendic, and micaceous schists, and bends round on itself in a sharp curve immediately north of the Kappatgode, thus forming an anticlinal ellipsoid, which is crossed by the road running from Dambal to Soortoor. To this series I will give the name of the Dhoni series, from the village of Dhoni, which stands on it. This series is noteworthy, because containing several important beds of grey and greenish-grey crystalline limestone of considerable thickness, which would yield a building stone of great beauty and excellence, and far cheaper to work than any of the granitic rocks of the neighbourhood. If pure enough to yield good lime on burning, it would prove of great value in the event of the railway extension between Bellary and Hoobly being carried out, through a country otherwise poor in limestones. The principal beds lie in two groups, the one 2 miles north-west of Dhoni, the other 3 miles west-south-west of that village. Overlying this to the westward are other hæmatitic beds, the representatives doubtless of those before named, if not, indeed, the extensions of the same. As these beds form the mass of Kappatgode Hill, I will call them, and their more northern representatives, the Kappatgode series. The character of the associated schistose beds has changed, however, from chloritic to argillaceous, and the predominant color of the rocks from green to reddish buff or mottled whitish. Owing to the great development of cleavage, the true dip of these argillaceous schists is in many places perfectly obscured, and their relation to the rocks next following them to the westward very problematical. This next series consists of chloritic and hornblendic schists, intimately associated with a massive dioritic rock. This dioritic rock, though in parts strongly resembling some of the diorites forming the trap-dykes, which occur so frequently in the gneissic region, does not appear to be an irruptive rock, but rather a product of excessive metamorphism. The schistose rock appears to pass by imperceptible graduation into the highly crystalline mass. Nowhere did I find the two dissimilar rocks in close apposition, but everywhere some feet or yards in thickness of rock intervened, showing the graduation of the special characters. This series, which I will call the Soortoor series, after the large village of that name, at which the principal gold washing is carried out, occupies a band of country some 4 to 5 miles broad, which is bounded to the westward by a band of granitoid gneiss of undetermined breadth. The position of this granitoid band (which may be called the Moolgoond series) relatively to the Soortoor series is uncertain; but it is probable that the latter series is the younger of the two.

All the streams said by the natives to be auriferous rise within the limits of the tract occupied by the Soortoor series; and the upper course of the Soortoor nullah, the richest of all, lies entirely within the area occupied by the pseudo-diorite, and associated chloritic schists.

Quartz reefs in the Soortoor series.

Quartz reefs occur in all the rock series above enumerated, but those lying within the limits of the Soortoor series are the best defined, and, with a few exceptions, have the most promising lie, their direction being mostly north-by-west, south-by-east, or parallel to the strike of the bedding. The surface of the principal reefs has been much broken up, doubtlessly by gold-seekers.

The quartz reefs occurring in the other series are mostly well defined, and, with two or three exceptions, run in different directions. Many run in the lines of strike of the bedding, but many cut across it in various directions.

Auriferous reefs in the Kappatgode series, or Huttee-Kuttee reef.

The most remarkable quartz reef in the whole auriferous tract, and the only one from which I succeeded in obtaining gold, lies about a quarter of a mile east of the eastern boundary of the Soortoor series, on the eastern slope of a ridge lying north-west-by-north of Huttee-Kuttee, a small village on the road between Dambal and Soortoor. This reef, which runs north-by-west, south-by-east, lies in the line of bedding of a series of reddish ferrugino-argillaceous schists with chloritic bands, both containing numerous cubical crystals of pyrites now converted into limonite by pseudomorphosis. The reef is rather less than half a mile in its entire length, and only in a small part of this is it a well-marked vein. Both the southern and northern extremities are very irregular, thinning out to a mere thread, or a few parallel threads in places, and then swelling into bunches, to thin out again a few feet further on. The reef does not cross the valley of the Guleeguttee nullah to the north, but thins out and disappears on the side of the ridge. The quartz is the ordinary dirty white variety, and includes a few little scales of chlorite along the lines of jointing, together with occasional cubes of pyrites, which, like those in the schists, have been pseudomorphosed into limonite. Parts of the quartz are ferruginous, the impure oxide of iron occurring in strings and lumps. The specimen of gold I obtained here is imbedded in such a ferruginous string. Though very small, it is quite recognizable, and shows a great resemblance to various pieces of stream-gold obtained by washing. It is of a very rich color. The piece of quartz containing it lay among the débris, beside the top of the reef at its highest part, where it has been much broken up by gold-seekers, by whom irregular mining operations have been carried on along the course of the reef. Much of it has been completely broken up, and the hill side thickly strewn with fragments. Three rude sinkings hardly deep enough to deserve the name of pits, and a considerable length of shallow trenching along the course of the vein, remain still visible. Besides these, there is an old pit sunk on the east side of the wall-like part of the reef some little distance down the slope, probably with the object of ascertaining the continuity in depth of the reef. This seems to have been sunk by some one having more advanced ideas than the authors of the diggings on the back of the reef; but I could ascertain nothing certain or satisfactory as to whose work it had been. To the north-west of the reef a number of little short veins and bunches of quartz had been attacked in shallow trenches, and had had their surfaces knocked to pieces by the same people, who were, according to my guide (a coolie from the village of Dindoor), a company of native goldsmiths who lived in the now totally deserted village of Guleeguttee (Kubun Kutkuttee of the Revenue Survey Map). These works had been carried out at some period prior to any time within the memory of my informant. The patels of Dhoni and Soortoor and others, of whom I enquired concerning these diggings, either could not or would not give me any information about the people by whom they had been made. I am rather inclined to suspect that the pit last mentioned was sunk by the Manager of a Gold Company which was got up during the Bombay share mania, and which Company, under the guidance of a practical Australian miner, sunk a lakh and a half of rupees in the search for auriferous quartz, and obtained no returns but a few small nuggets of *Australian* gold, sent down from time to time by the judicious manager to allay the anxiety in the shareholders' minds till a convenient season came for him to disappear without having accounted for his expenditure. The only positive trace of his proceeding which I came upon or heard of was a pit about 15 feet deep, sunk on the south side of a quartz reef belonging to another series lying south of the village of Dhoni.

The Huttee-Kuttee reef is about 5 feet thick on the average, where well-defined and wall-like. The strike, as before-mentioned, is north-by-west, south-by-east, with an easterly dip of from 40° to 50°. Much of the reef has been broken down, but a length of about 35 yards remains like a cyclopian wall, and forms a very conspicuous landmark from the east.

Reefs in the Dhoni series.

The only other reefs deserving separate mention form a group lying about a mile to a mile and a half south of Dhoni village, on the north-east flank of the Kappatgode mass. Unlike the reefs already referred to, the reefs in this group consist, not of ordinary milk-white quartz, but of a distinctly bluish or deep grey diaphanous variety, with a varying amount of enclosed scales of white or pale mica. These reefs may, according to their courses, be assigned to two subordinate groups, of which the one was north-west by south-east, the other north-east-by-east, south-west-by-west. The members of the latter sub-group are much the best defined, and form dyke-like veins 5 to 6 feet wide and from 400 to 600 yards long. The other set, lying on the east side of the small stream, which flows from the north-east side of the Kappatgode into the Dhoni nullah, a little east of the village of Dhoni, are less well-defined veins, but of considerably greater length than the former.

None of the reefs in the Dhoni series run in the lines of bedding of the chloritic, hornblendic, and micaceous beds they traverse; but there are a very large number of bunchy strings of quartz of the ordinary milky white variety which run in the lines of both bedding and cleavage, but all of a size far too small to show on any but a very large-scaled map. These, as well as the diaphanous quartz reefs, contain remarkably little iron oxide; the superficial staining they show is due mainly to the decomposition of included portions on the surrounding rock.

The remaining quartz reefs noticed in the auriferous tract on the east flank of the Kappatgode, on the west flank of the ridge running north and north-west from the Kappatgode, and in the valley to the north-west of Dhoni village, are all of the ordinary variety of quartz running more or less in the strike of the bedding, and presenting no noteworthy peculiarity. As in all schistose rocks of the ordinary types, an immense quantity of free quartz occurs throughout their mass, in the form of laminæ, strings, bunches of all possible sizes. It is from these, rather than from the débris of larger veins in reefs, that the innumerable lumps of quartz covering the face of the country generally are derived. As the country is in most part utterly devoid of any vegetation except grass, all the larger occurrences of quartz are conspicuous objects in the landscape, need but little searching for, and are easily prospected.

Reefs in which a sulphide was found.

The almost invariable association of gold with the different sulphides of iron, lead, copper, &c., in quartz reefs, is well known; and hence in prospecting the reefs I have before referred to, I paid great attention to the indications of the presence or absence of sulphides, besides searching for metallic gold. In only three did I obtain positive evidence of the existence of a sulphide—the sulphide of iron—in the form of cubical pyrites. These three were the Huttee-Kuttee reef and the two parallel reefs to the east of Venkatapoor, but the number of inclosed crystals is in each case very small. It is largest in the Huttee-Kuttee reef. Much of the quartz in the different reefs is what the Australian miners technically call "mouse eaten;" that is, full of cavities formed by the weathering out of other mineral substances which had been enclosed. In the great majority of cases it was clear from the form of the cavities left that the enclosed minerals had been chlorite or hornblende. None of the cavities were cubical. In one reef in the Dhoni group I noticed some small and rhomboidal cavities, probably due to the removal of enclosed crystals of calcspar. Free gold is often found left behind in such cavities in really auriferous reefs in Australia and elsewhere; but none was met with here. All the reefs observed lie above the surface of the surrounding country, and have hence been far more exposed to weathering influences, which might account partially for the absence of sulphides in the reefs, but which will not account for the absence of the characteristic cavities they should have left behind.

From the great paucity of sulphides a proportionate paucity of gold is to be reasonably inferred in the reefs of the Kappatgode area. I must have broken off several hundred pieces of quartz while prospecting, but not one contained any visible gold; while that found loose at the Huttee-Kuttee reef contains but a very small quantity—a mere speck. A number of carefully selected samples was brought away from the most promising looking reefs, to ascertain whether they contain gold in so finely divided a state as to be invisible to the naked eye, which is frequently the case in Australian and Californian reefs. These were assayed at the Calcutta Mint through the kindness of Colonel Hyde, and in the Survey laboratory by Mr. Tween, but none of them yielded any gold.

Even if the reefs were moderately auriferous, the pioneers in mining operations would have many serious difficulties to contend against; the distance from the coast, and at present from any railway, would make the setting up of machinery very expensive. No timber or fuel of any kind is obtainable except at very great distances, and water would be very scarce except through the rainy season.

ALLUVIAL GOLD.

Gold-washers called Jalgars.

The washing for gold in the sands borne by the various streams flowing through the auriferous tract is carried out by a class of men called Jalgars, and they are now very few in number compared to what is reported about them in former years. I could only hear of three, two of whom were at Soortoor, and the third lived at Seerhuttee, in the Sangli Jaghir. I obtained the services of the two former, and made them wash for me in the Dhoni, Soortoor, Jilgerree, and other nullahs on the west flank of the Kappatgode. Of these nullahs, the Soortoor nullah was by them stated to be the richest, and this statement was fully borne out by the results obtained when washing there in my presence. Next in productiveness came the Dhoni stream, but the yield was greatly smaller, and hardly enough to remunerate them for their labour. In the Jilgerree nullah they got a yet smaller return; and in the other nullahs, including that at foot of the Kappat Iswara ravine, only a very few exceedingly minute spangles were obtained, just sufficient to show that gold was not entirely absent from the detrital matter.

Process of selecting wash-dirt.

The plan pursued by the Jalgars when I let them follow their own devices, was to take up the lower part of the latest flood deposit from the rocky or clayey bottom of the nullahs, not from the deepest part of the bed, but from the point at which a strong length of current slacked off, owing to a change in the direction of the stream. Another favorite sort of place from which to collect 'wash-dirt,' was the small alluvial terrace between the water at low flood level and the present high flood level. From this they collected the rain-washed surface, and in the case of the washings in the Soortoor and Jilgerree nullah, obtained much better results than from washing the material obtained in favorable positions from pockets in the beds of either nullah. In another washing in the Soortoor nullah, the wash-dirt selected was the kunkur crust deposited on the decomposing surface of a band of chloritic schist. This was altogether the richest washing made in my presence. Unfortunately the proceeds of this washing were, by inadvertence, mixed up with those of another, going on at the same time a little further down the nullah. The united results were said by the Jalgars to be a very good day's work. The second washing was made from a stuff collected at the base of the old alluvium bank, which there consisted of a bed of coarse shingle mixed with clay and fine ferruginous pisolitic gravel (a product of decomposition of iron pyrites), overlaid by black clay followed by a second but rather less coarse bed of shingle, on which rested the regur forming the soil of that part of the valley of the Soortoor nullah. The yield of this washing was rather less than that of the last mentioned. For the two washings I had four men at work for three hours at a place of their own selection—their favorite place according to their assertion; two men washed and other two dug and carried the material to the washing place. The quantity of wash-dirt put through the washing box, I estimated at 1½ cubic yards, from which the quantity of gold obtained weighs a trifle over 6½ grains, worth 9 annas in round numbers, at the rate of £3-17-6 for the ounce (troy) of gold.

Section of alluvium at Soortoor.

The method of washing adopted is simple, but might be made more effective at very little expense. The wash-dirt is scooped up with a small stout, broad hoe with a short handle, and carried in a basket or large wooden tray to the washing box, which has been fixed at the water's edge and propped up with stones to the required slope. The washer sits on a large stone in the water close to the side of the box, which is an oblong construction, made of light planks and open at one end. It is about 3 to 3½ feet long, 20 inches wide, and 9 inches deep, and strengthened with clamps. A stick of some elastic kind of wood is jammed against the sides and bottom at the lower and open end to form a catch. This done, the washer begins to ladle water on the wash-dirt, kneading it the meanwhile with the left hand and throwing out all the larger pebbles. The ladle or rather scoop used by the Jalgars was made of a long calabash, with one end cut off. It was held by the middle, an oblong hole having been cut into the incurved side, and a couple of small sticks tied across diagonally to the corners and fixed with strings passed through small holes. The elder man of the two, however, preferred to use a tin pot with cross handle, which had been given him by a former Collector of Dharwar. This goes on till a layer of sand has been formed in the box, so thick that the stick at the lower end is no longer a sufficient catch, and a second stick is jammed in and the washing process re-commences till the sand layer has risen almost level with the second stick; both sticks are then removed, the washer stirs up the layer of sand with a short, stout piece of wood and then sweeps everything into the large wooden tray held below the open end by the assistant. The washer then takes the tray, places it in the water, and performs the needful shaking and washing, technically called "panning off," till nothing remains at the bottom but fine sand, generally of black color. He then tilts the tray a little, and by judiciously dropping water out of his hand on the small layer of sand drives all the lighter particles forward and leaves the spangles of gold exposed. This small residue is then collected carefully by washing down into a half cocoanut shell, and taken home to be treated with mercury.

Process of washing.

From the shortness of the washing box and the very rude way of stopping the open end, and from the evidently careless style of manipulation, there must be considerable waste. Much better results would doubtless be obtained by using a box more like the Californian "Long Tom," which is generally 12 feet long, 20 inches wide at the top, and widening to 30 inches at the open end, besides being furnished with various ledges to catch any heavy material. The first man who wrote about the Kappatgode gold tract—that admirable observer, Captain Newbold, F. R. S., whose early death was so great a loss to the cause of science generally in India—was also of opinion that the washing was very carelessly and wastefully performed. My friend, Major Bartholomew, Superintendent of Police in Dharwar District, who with me watched the Jalgars at work in the Dhoni nullah, was, like myself, much struck by the rudeness of their appliances and the careless way in which they proceeded. I find it difficult, therefore, to understand the verdict of a Mr. J. Scholt, apparently a practical miner,

Process of washing susceptible of improvement.

who wrote in a letter to the *Times of India* (quoted in Balfour's Cyclopædia of India, article Gold), that he never in his whole experience met with such careful and effectual washing as that of the Kappatgode Jalgars, surpassing even the Chinese, who, in Australia, were considered perfection in that respect.

Small extent of workings.

The Jalgars ply their trade of gold washing only after heavy rains, and, as the Soortoor men informed me, for one month in the year, during which no agricultural operations are in progress. Their earnings are very various, and range from 5 to 50 rupees in a season apiece. They affected not to know of any gold *in situ*, and told me I was wasting my time in prospecting the quartz reefs. As it might be an idea of policy in their minds to keep to themselves as much of their knowledge as they fancied convenient, it would not be safe to attach too much evidence to their statements but that they were borne out by the statements of the patels of Dhoni and Soortoor, and numerous other villagers, whom I questioned through Major Bartholomew, who kindly acted as my interpreter to the Canarese people. The same information had been given me by the mamlatdar of Chikkodi, in Belgaum District, a shrewd Brahman, who had been for a considerable period the mahalkare of Moolgoond close to Soortoor. The mamlatdar of Gudduck also confirmed the information I had previously obtained.

Captain Newbold, in his resumé of information about gold tracts, published as No. 4 of his papers "On the Mineral Resources of Southern India," speaks of the banks of the auriferous nullahs being crowded with Jalgars after heavy rains—a very different state of things from what now prevails, and from which it may be inferred that the yield of gold has greatly diminished. It is very likely that such is the case; but another cause which has had great influence in diminishing the number of gold-washers may, I think, be found in the greatly increased prosperity prevailing in Dharwar District, since the American war created such a demand for cotton that immense wealth was poured into the district and gave a strong impetus to all sorts of other and more certain industries which have absorbed the great number of half idle men, who in former years devoted themselves to gold hunting in the rainy season.

Mr. Scholt's estimate of the alluvial gold.

Another writer on the Kappatgode gold tract—the Mr. Scholt, already quoted—formed a very low estimate of the alluvial gold return. According to the epitome of his letter to the *Times of India* given in Balfour's Cyclopædia, he confidently stated that the alluvial deposits would never pay, as the deposits in which the gold occurs are confined to a few insignificant nullahs and "blind water-courses" occupying the slopes and flats, the bed-rock in every case being exposed more or less, denoting a very scanty supply of wash-dirt, the native gold-washers (a very limited body) confining their operations to a stratum not exceeding 5 inches in depth. Twelve days' work at Soortoor yielded to Mr. Scholt from 2 to 3 rupees worth of gold (about a pennyweight).

I have already mentioned that the Jalgars did not try to get wash-dirt from deep pockets in the beds of the streams, the situations generally found most productive in the Australian and Californian gold washings. It was impossible to try the most promising places in the several nullahs at the time of my visit owing to the constant heavy rains. In the dry weather they might, however, be excavated by damming back the little streamlet that would alone remain then, and by simply baling out the hollows; but very little water would be then available for washing. The probability is that a little more gold would be found, but that as that operation has doubtless been carried out in former times by the natives themselves, no wonderfully rich pockets would be found to repay expenses; for it must be borne in mind that the inhabitants of the Kappatgode region are not ignorant savages like the Australians, who did not know the value of the precious metal.

Outturn of gold

The annual outturn of wash gold from the Soortoor, Hurtee, and Dhoni nullahs, was estimated by Captain Newbold to be about 200 ounces after an average monsoon. What it may be at present, I did not succeed in ascertaining, but I think it may be safely set down at less than the tenth part of the former amount. The fact that so very few are attracted to the gold washings at present, appears to my mind very strong evidence of its not being a very profitable occupation. The poverty of the reefs is borne out by the very small yield of alluvial gold; and the inevitable conclusion appears to me to be that there are not sufficient prospects of success to justify any outlay of capital in mining works on a large scale.

Other metals found with the gold sand.

The stream-gold is found associated with a black sand consisting mainly of magnetic iron in minute octohedra. and a black residue not affected by the magnet In the sand washed in the Dhoni nullah, I found several minute rounded grains of a grey metal, which on further examination proved to be metallic silver. A couple of little spangles of pale yellowish silvery hue were also obtained, which are doubtless electrum, the natural amalgam of gold and silver; beside these were a few minute grains of bronze colour, which on examination proved to be a mechanical mixture of metallic copper and oxide of tin. Newbold mentions having found a small fragment of metallic copper. grains of silver, and a few whitish metallic spangles which he took to be platinum; a supposition which does not seem, however, to have been substantiated. He also found gray silver ore in a fragment of quartz, but did not trace the source from which the quartz had come; nor was I more fortunate in that matter. In a green colored and very trap-like part on the pseudo-diorite, lying about a mile north-west-by-north of Soortoor, I found very numerous octohedra of magnetic iron of minute size, but very perfect, with numerous little lumps of copper pyrites and some iron pyrites. Iron pyrites of very white color, in minute parcels, is also widely dissemminated in an adjacent black variety of the pseudo-diorite.

Notes on previous observers.

Captain Newbold's notes on the geology of the gold tract are very brief, but, like all his observations, very correct. The Kappatgode gold region was subsequently visited and described by Lieutenant Aytoun, of the Bombay Artillery, but his description is unfortunately very meagre. He speaks of an exceedingly great development of iron pyrites in the gold region, and he observes that, "were it not that all the conditions on which the large development of the precious metals depends are here found in conjunction with the pyrites, it might be imagined that the small quantity of gold now found in the nullahs in this part of the country was derived from this source. Iron pyrites, as it is well known, often yield a small amount of gold." To my judgment the development of iron pyrites is small, except in the argillaceous schists near Huttee-Kuttee, in which the cubical crystals are found in moderate numbers. Lieutenant Aytoun does not appear to have traced the gold to its matrix, though he inferred correctly that it is found among the chlorite slate hills to the west. He mentions having obtained occasionally "small pepites of gold of a pear shape," but does not give the localities where they were found. His sections illustrating the geological structure of the hill group are correct in the succession of rocks shewn, but in various parts he seems to have taken the planes of slaty cleavage for planes of bedding.*

Dr. Carter, in his Summary of the Geology of India, in referring to Mr. Aytoun's paper, speaks of two hills, called the "Great" and "Little" Gold Mountains. These names seem to have gone out of use now, or to have no reference to the occurrence of the precious metal.

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* Geological structure of the basin of the Jhalpurba in the Collectorate of Belgaum, including the Gold District, by Lieutenant Aytoun, of the Bombay Artillery. Transactions of the Bombay Geographical Society, Vol. XI. page 8; also reprinted in Carter's Geological Papers on Western India.

They were not mentioned by the Patel of Dhoni when pointing out all the different places seen from the summit of the Kappatgode.

Mr. Gilbert Elliott of the Bombay Civil Service, now Collector of Kuladgee, visited the gold tract in 1856; but I am unaware whether he wrote any report on it at that time. I think, however, that if he had re-visited the Kappatgode and the other gold localities with the practical knowledge of gold mining and prospecting he has since acquired in Australia, he would not lately have written so sanguinely about the prospects of gold mining in Western India.

My visit to the Kappatgode was greatly facilitated by the great assistance and personal kindness I received from Mr. Elphinstone Robertson, the Collector of Dharwar, and Major Bartholomew, Bo. S. C., the District Superintendent of Police, to whom my best thanks are due.

OTHER AURIFEROUS LOCALITIES IN DHARWAR, BELGAUM, AND KULADGEE DISTRICTS.

Gold occurs but only in very small quantities at several other places besides the Kappatgode region. Chick Moolgoond in the Kod Talooka of Dharwar District, which I was unable to visit from its distance, is mentioned by Newbold.

Lieutenant Aytoun mentions both Byl Hongul and Belowuddee, in the Sampgaum Talook of Belgaum District, as auriferous localities; but in the case of the former gives no particulars by which to proceed in making search: he merely refers generally to the occurrence of gold sand in some streams. There are very few indications of quartz, except such as occur in laminæ and bunches in the chloritic schist. I only found one small reef which was of diaphanous blue grey quartz, containing no visible gold and no sulphides of any kind. The people at Byl Hongul maintain that gold is unknown there, a statement confirming the report of the talook officials to the Collector of Belgaum with reference to enquiries I made of him. I visited the auriferous nullah of Huttee-Kuttee, an abandoned village near Belowuddee, but was unsuccessful in washing, and a series of samples of the alluvial detritus which I brought away proved on chemical examination by Mr. Tween to contain no gold. A sample of the auriferous sand which I obtained through the Collector of Belgaum was also found to contain no gold. The Patel of Belowuddee informed me that no gold has been washed during the past ten years. The Jalgars who used to frequent this locality came from Hoobly, in Dharwar District. The sand of this nullah contains very little magnetic iron, the almost constant associate of gold.

All the evidence obtainable is not favorable to the idea of gold being found here in any considerable quantity. What little has been found, was probably derived from some quartz reef traversing either the chloritic schists or the pseudo-diorite on which the nullah in question rises. I did not observe any reef in the valley, but much of its surface is masked by cotton soil or ferruginous débris formed by the decomposition of beds of hæmatitic schist which occur in large numbers in the gneissic series. These are the 'jaspideous iron beds' of Mr. Aytoun's report, which he holds to be analogous to the quartz ranges and metamorphic parallel bands of the Ural Mountains and Australia, and thinks they will be found to characterize the gold zone of Belgaum District.

Moorgod, in the Pursgurh Talooka of Belgaum District, is another locality where gold is obtained in small quantities. Unfortunately I was not aware of this when there, and had not an opportunity of re-visiting the place afterwards. My informant, the present mahalkare of Chandgurh, Belgaum Talook, a very intelligent Brahman, who had been mahalkare of Moorgod for some years, told me that from 150 to 200 rupees worth of gold is annually collected in one of the nullahs near the town. The Jalgars in that case are poor Mussalmans. The gold most probably comes from small quartz veins in the chloritic schists, which are largely developed west of the town. I am inclined to regard this series of chloritic rocks as occupying the same horizon as the Kappatgode series; but this cannot be determined till the geology of the intermediate country shall have been worked out.

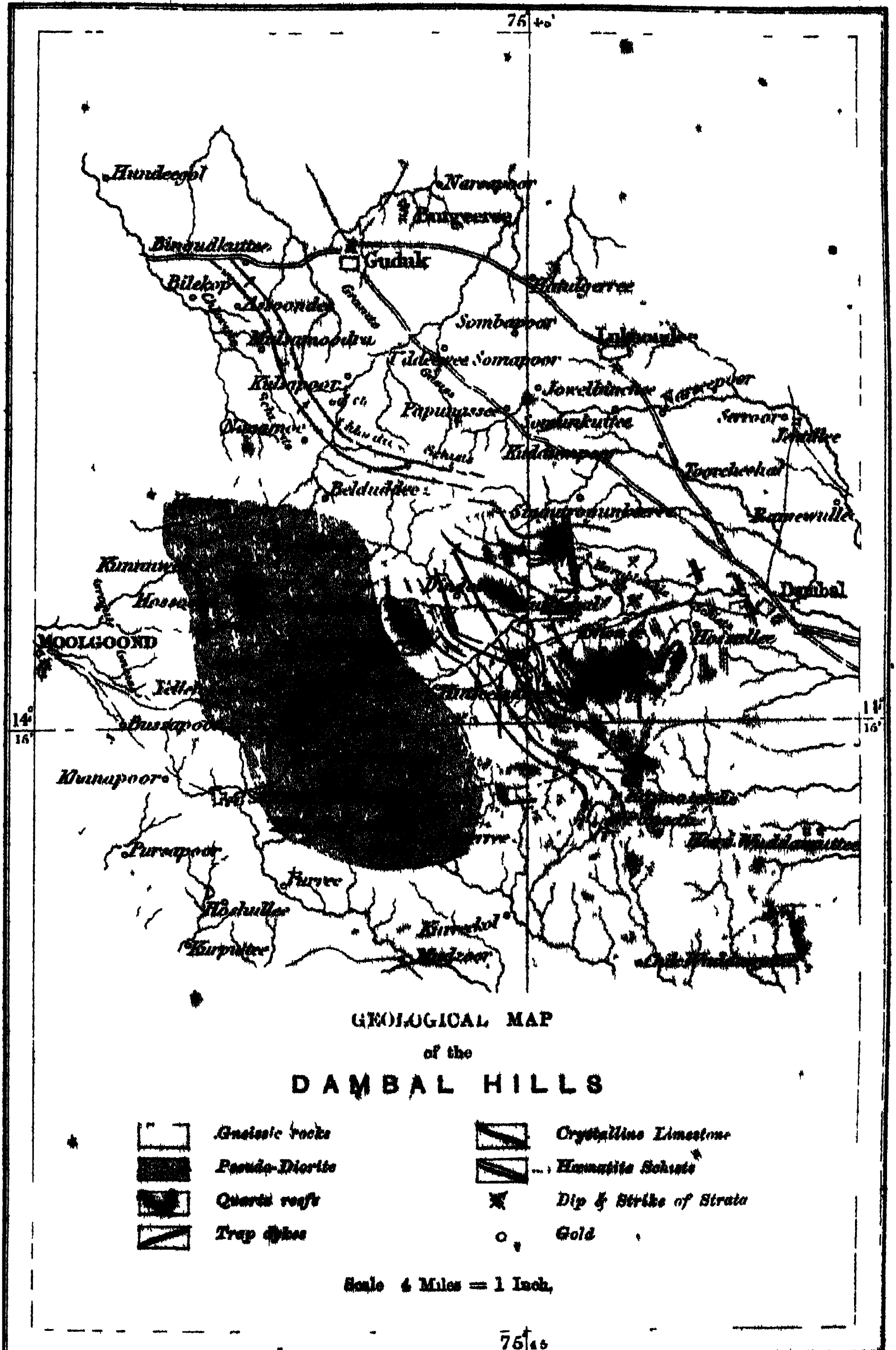
Gold is said to occur at Sogul, four miles south-east of Moorgod, but I could not ascertain which of the two nullahs near the village contains the auriferous sand. The existence of gold there is denied by the talook officials, so it cannot be found in any great quantity.

The last place reported to yield gold is Gooludegud, in the Badami Talook of Kuladgee District. I am inclined to doubt it altogether, as I did not hear of it, though I visited the place three times. It could hardly have been unknown to the German missionaries of the Basle Society who are located there, and I should have certainly heard of it from them.

REMARKS ON CERTAIN CONSIDERATIONS ADDUCED BY FALCONER IN SUPPORT OF THE ANTIQUITY OF THE HUMAN RACE IN INDIA, *by* W. THEOBALD, *Geological Survey of India.*

Few of the writings of the illustrious Falconer possess greater interest to the geologist or anthropologist than the paper entitled "Primeval man and his cotemporaries," written in 1863 (*vide* Falc. Memoirs, Vol. II., page 570), or display bolder or more forcible speculation on a question foremost for interest among those to which the attention of the great palæontologist had been devoted. The question, moreover, is an eminently living one, and great as have been the discoveries already achieved, we may confidently expect still greater accessions to our knowledge of it in the future, especially that particular branch of it relating to India, and the existence of man there, during the latest tertiary times. Whilst, however, every advance in knowledge has tended in the direction of Falconer's arguments, and rendered increasingly probable the main conclusions he advocated, there are certain facts of which he was ignorant, which materially diminish the force of one of the arguments he employed in support of his general proposition.

The first argument in favor of the co-existence of man and the extinct animals of the Sivalik Fauna, was the probability that the idea of a gigantic tortoise met with in the Pythagorean and Hindu Mythology had originated in a traditional acquaintance with the huge *Colossochelys atlas*, which in size was physically comparable with and capable of contending on equal terms with the largest elephant. The tortoise on which the elephant stood which sustained the world, the second Avatar of Vishnu in the form of a tortoise, and the elephant and tortoise which during their combat were borne off and devoured by the bird Garúda, are adduced as instances of this idea. "In these three instances, taken from Pythagoras and the Hindu Mythology, we have reference to a gigantic form of tortoise, comparable in size with the elephant. Hence the question arises, are we to consider the idea as a mere figment of the imagination, like the minotaur and the chimæra, the griffin, the dragon, and the cartazonon, &c., or as founded on some justifying reality? The Greek and Persian monsters are composed of fanciful and wild combinations of different portions of known animals into impossible forms, and, as Cuvier fitly remarks, they are merely the progeny of uncurbed imagination; but in the Indian cosmogonic forms, we may trace an image of congruity through the cloud of exaggeration with which they are invested. We have the elephant then, as at present, the largest of land animals, a fit supporter of the infant world; in the serpent Asokee, used at the churning of the ocean, we may trace a representative of the gigantic Indian Python; and in the bird-god Garúda, with all his attributes, we may detect the gigantic crane of India (*Ciconia gigantea*) as supplying the origin. In like manner, the *Colossochelys* would supply a consistent representative of the tortoise that sustained the elephant and the world together. But if we are to suppose that



GEOLOGICAL MAP
of the
DAMBAL HILLS

the mythological notion of the tortoise was derived, as a symbol of strength, from some one of those small species which are now known to exist in India, this congruity of ideas—this harmony of representation, would be at once violated; it would be as legitimate to talk of a rat or a mouse contending with an elephant as of any known Indian tortoise to do the same in the case of the fable of Garúda. The fancy would scout the image as incongruous, and the weight even of Mythology would not be strong enough to enforce it on the faith of the most superstitious epoch of the human race."—Page 575.

The above argument is plausible, if it may not be termed forcible; but since it was written, additional light has been thrown on the subject, and it has been ascertained that the Fauna, habitually referred to by Falconer as the *Sivalik*, in reality comprised two Faunas, derived from two perfectly distinct groups, which were first discriminated by Mr. Medlicott (*vide* Memoirs, Geological Survey, Vol. III.) under the names of Náhan and Sivalik, in 1864. Now, the co-existence of man with some, at least, of the extinct members of the Sivalik Fauna, though not as yet established, is what the discoveries of any day may put beyond question; and were the *Colossochelys* a member of the more recent, Sivalik, fauna, Falconer's argument, quoted above, would, in my opinion, have great weight: but we now know that *Colossochelys* was not a Sivalik species but a member of the older Nahan fauna, no species of which is certainly known to have survived to Sivalik times. *Colossochelys* was among the fossils forwarded by Colonel Burney from Ava, where it was associated with *Mastodon latidens*, Clift, and *Elephas Cliftii*, Fal. (*Mastodon elephantoides*, Clift, in part). Now, both these mammals are Náhan species, and during the last season a superb palate specimen of *E. Cliftii*, Fal., was procured by myself from Náhan strata, near Talowra, on the Sutlej; whilst *Mastodon latidens*, Clift, was recently procured near Lehri, not far from Jhelum, by Mr. Wynne, accompanied by *Sus hysudricus*, Fal., both fossils differing considerably from Sivalik remains in aspect and mineralization. I have not visited Lehri, but I have good grounds for believing the fossils from it to be all of Náhan age, though this I need not enter on here. I have also myself procured during the last season specimens of *Colossochelys* from Náhan beds near Deyra or the Biás, so that the evidence of the geological age of this remarkable form is tolerably complete. This being so, any arguments short of direct proof of the co-existence of man and the *Colossochelys* are vain; since, with the enormous gap intervening between the groups, it is far more unlikely that remains of man will be ever found in the older, than it is probable that they may be discovered in the younger.

The second argument I would refer to is contained in a paper by Falconer, published posthumously in the Quarterly Journal of the Geological Society for November 1865, and reproduced in the Falconer Memoirs, Vol. II., p. 632. I cannot do better than give the passage as it stands: "The third fossil species (*Hippopotamus Palæindicus*) is perhaps the most important in its indications. A quadruped, so remarkable for its size, form, and habits, must everywhere have forcibly impressed itself on the attention of mankind, and struck with the close resemblance of the Nurbuda fossil buffalo to the existing species, the question arose with me: 'May not this extinct hippopotamus have been a contemporary of man? and may not some reflection of its former existence be detected in the extinct languages or ancient traditions of India, as in the case of the gigantic tortoise?' Following up the enquiry, I ascertained from the profound Sanskrit scholar, Rajah Radhakanta Deva, that the hippopotamus of India is referred to under different Sanskrit names of great antiquity, significant of 'jala hasti,' or 'water elephant,' in the 'Amarakosha' and 'Subda-ratnavali.' This view is confirmed by the opinion of two great Sanskrit scholars, Henry Colebrooke and H. H. Wilson. The former in his annotations on the 'Amarakosha' interprets the words 'Gráha' and 'Avahára' as meaning hippopotamus; and the latter not only follows this version, but gives two other words, 'Kariyádus' and 'Vidoo,' which he supposes to signify the same animal. It is therefore in the highest degree probable that the ancient inhabitants of India were familiar with the hippopotamus as a living animal, and it is contrary to every probability that this knowledge of it was drawn from the African species imported from Egypt or Abyssinia." Considering the important issue here raised, I felt it would be extremely desirable to obtain some confirmatory opinion, if possible, of the philological question involved, and accordingly addressed a note to my old friend, Baboo Rájendralála Mitra, stating the case and requesting his opinion as to whether or no any Sanskrit words were known which could certainly be referred to the hippopotamus. His reply was strongly negative of the idea, and I give it in full.

"The *jalahastí* does not occur in the *Amarakosha*, but in some of its commentaries it is given as a synonym of *avahára*. In the *Nágánanda*, a Sanskrit Buddhist drama, *jalakunjaras* are described as sporting in the waters of a river. *Kunjara* is but another word for *hastí*. The counterpart of this occurs in the *Rájatarangini*, where *jalagandhebha* is used for *jalahastí*. Neither of these books, however, afford any clue to the nature of the animal they describe. The Sanskrit Dictionary of Böhtlingk and Roth gives 'wasser-elephant' on the authority of Hemasuri, who says it is an elephant-like animal, which dwells in water (*jaleshu hastyákárát vá*). The *Amarakosha* takes the *gráha* and the *avahára* to be the same animal, which, according to one commentator, is the same with the shark, *hángara* (*hángarákhye jala-jantau*); and according to another, a slender, long animal that frequents the confluence of large rivers with the sea (*samudra-mahánadyoh sangame latákára jantu viseshah*). At least half a dozen others add to the above definition 'commonly known by the name 'hángara' (shark), but not applicable to crocodiles;' and I see no reason to differ from them. There is nothing in any Sanskrit work which can be accepted as a positive proof of the *jalahasti* being other than the *gráha*, and was used to indicate the hippopotamus. I must add, however, that Wilson, in his Sanskrit Dictionary, gives the word hippopotamus against *avahára* with a mark of interrogation. He has not given the word *jalahastí*."

After perusing the above remarks of so eminent a scholar, I think few will be inclined to attach much weight to any argument resting on so insecure a philological base as the above is seen to be; indeed there is a more formidable difficulty even than the above uncertainty, as to what animal was really meant, in the fact of the words presumed to signify hippopotamus being of Aryan origin, which would at first seem to carry forward the presence of the hippopotamus in India to so late a period as the Aryan occupation of the country. To this length Falconer, however, does not go, as he remarks with respect to this difficulty—"After reflecting on the question during many years in its palæontological and ethnological bearings, my leaning is to the view that *Hippopotamus namadicus* was extinct in India long before the Aryan invasion, but that it was familiar to the earlier indigenous races" (Memoirs, Vol. II., p. 644). Without, then, questioning the probability that this was the case, I think that it must frankly be admitted that the philological argument is totally insufficient *per se* to establish such probability.

It remains, however, to determine what animal the *jalahastí* really was. It was clearly an unwieldy animal frequenting rivers, and not the crocodile. The supposition of most commentators that it was the 'shark' was probably due to the fact that they were acquainted with no more likely animal to which to refer it, though there is no possible similarity or points in common between a shark and an elephant to render it probable that the old Aryans bestowed the name water elephant on the former animal. The observation of one of the commentators quoted by Rájendralála Mitra, to the effect that it frequented the junction of large rivers with the sea, (though coupled with the remark of its being long and slender, which no elephant-like animal can properly be called,) seems to throw a light on what may possibly be the animal intended; for having witnessed the awkward evolutions of dugongs sporting of an evening on the oily expanse of still sea at the mouths of rivers on the eastern side of the Bay of Bengal, I can well understand how the term 'water elephant' might be applied to that animal whose heavy massive head and bulky form, imperfectly perceived beneath the water, is suggestive of somewhat elephantine proportions. I offer the suggestion, however, merely for what it is worth, and as one certainly more probable than that the 'water elephant' can be either a shark or any slender animal or fish, whilst the probability of its being the hippopotamus is one involving too serious issues to be adopted on the slender grounds alone of verbal applicability.

KASAOLI, July 9th, 1874. W. THEOBALD.

GEOLOGICAL NOTES MADE ON A VISIT TO THE COAL RECENTLY DISCOVERED IN THE COUNTRY OF THE LUNI PATHANS, SOUTH-EAST CORNER OF AFGHANISTAN, *by* V. BALL, M. A., *Geological Survey of India.*

In the following pages I purpose giving an account of the geological structure of a portion of country which, being situated for the most part beyond the British frontier, where internal strife and raiding is the normal state of things, is one which, except under such special arrangements as were made on the present occasion, could not be visited by a geologist.

For this reason it is important to put on record even the somewhat imperfect observations which were made during a few days hurried ride through these little known regions.

Fortunately, the route taken by the expedition from the plains at Saki-Sarwa to the most distant point reached in the Chamarlang valley (about fifty miles as the crow flies) was more or less at right angles to the strike of the rocks and of the principal hill ranges, and thus in each day's march a section of the rocks was traversed which served to indicate the geological structure. The facility with which such rapid observation could be made being in a considerable measure due to the poverty of the vegetation* which was nowhere sufficient to hide the rocks, and thus the eye was enabled to trace individual beds through all their bendings for many miles. This freedom from jungle renders geologising on the north-west frontier a very different thing from what it is in the central parts of India and in the Himalayas, where, for the most part, the geological structure can only be ascertained by systematic plodding up the beds of streams and hill sides, and where a bird's eye view of the relations of the different formations is seldom to be obtained.

My observations being restricted to a limited portion of the great Sulimán range, I do not attempt at present any generalisations or even comparisons with the geologically known regions to the north and south, but shall confine myself as much as possible to an enumeration of the observations made in this particular locality. So far, then, as reference to previous notices is concerned, it is limited to the correspondence relating to the discovery of the coal, the examination of which was the object of my mission.

History of the coal.—The first discovery of coal in the neighbourhood of the Sulimán range, west of Dera Ghází Khán, was, in the year 1863, reported to the Officiating Deputy

* I am indebted to Mr. S. Kurz for the identification of a small collection of the most characteristic plants which occur in these hills.

Perhaps the most common tree on the hills is a species of olive (*Olea ferruginea*, Royle=*O. Europea* Var.). A flabelliform palm *Chamærops Ritchieanum*, the fruits of which are much sought after by the Biluchis, occurs on the hill slopes and in the valleys. *Daphne oleoides*, L., *Grewia populifolia* and *Dodonea viscosa* are also found on the hills. In the valleys, species of *Acacia* and *Tamarix* are not uncommon, and *Nerium odorum* and *Zizyphus jujuba* occasionally occur. Besides the above, several herbaceous plants, which it is useless to enumerate here, were also collected.

Commissioner, Captain W. M. Lane, by Sirdár Jamál Khán, chief of the Lagári tribe. Specimens were forwarded by the Lieutenant-Governor of the Punjab to the Geological Survey for report. The examination shewed that most of the specimens occurred free *in situ;* the fracture conchoidal; structure obscurely woody—one specimen splintery with a black streak, the other tough with a brown streak. Specific gravity 1·46. Water 13 p. c.

Composition—

Carbon	...	44·0
Volatile	...	50·5
Ash	...	5·5
		100·0

Traces of sulphur were observed.

The locality whence this coal had been brought was visited subsequently by the Deputy Commissioner of Dera Gházi Khán,* who wrote—"The best specimens were found in the Mithanwan pass, near Chota Bála, but even here the seams are so small that they would never repay the labour of working them. The seams of coal lie embedded in the rock chiefly of the sandstone formation."

After much labour for a whole day about 10 seers of coal was obtained "The largest veins are not more than 6 inches long and about 2 inches in depth." It was justly concluded that the deposit was not worth working. The above-mentioned coal from the outer (eastern) flanking hills of the main axis of the Sulimán range was, up to the year 1870, the only known example of the occurrence of the mineral in that latitude, although both to the north and south at Kálabág and at Lynah, in Sind, coal has been known to exist in limited quantities for a long time.

In 1870, the present Deputy Commissioner Captain R. Sandeman reported the receipt from some Biluchis of specimens of coal from a quite new locality situated in a range of hills ninety miles from the British frontier. The account given by the Biluchis represented the coal to be in considerable abundance, and as the assay of specimens which were forwarded at that time indicated a good coal,† it seemed probable that an important and valuable discovery had been made.

Accordingly, in the present year, a favorable opportunity occurring, Captain Sandeman paid the principal locality in the Chamarlang valley a visit, when, in a short time, 50 camel-loads of coal were collected by the Biluchis, and the impression formed from the appearances presented by the seam was that the coal existed in sufficient quantity to be of economic value. The coal collected on this occasion was forwarded to Lahore, where it was tried in a locomotive, and gave fairly promising results. At this stage it was determined that the locality should be visited and reported upon by an officer of the Geological Survey, and the following account embodies the results of the examination:—

Route.—Before proceeding to the detailed account of the rocks, I shall give a short sketch of the route traversed on the road to the coal.

* Letter to Secretary to Government, Punjab, Public Works Department, dated 26th November 1868.

† The composition of these specimens was as follows:—

Carbon	...	...	63·0
Volatile	...	...	34·4
Ash	...	...	2·6
			100·0

Leaving Dera Gházi Khán, which, though within the normal area subject to inundation from the Indus, is protected from injury by considerable dams, the road westward to Vuddore passes over for the most part cultivable land, broken here and there by tracts covered with drifting sand-dunes. Between Vuddore and Saki-Sarwa the soil becomes more arid and sandy, and cultivation is more restricted to what may always be called oases. The wild vegetation, consisting of species of *Tamarix*, *Zizyphus*, *Calatropis* and *Euphorbia*, indicating the character of the soil. At Saki-Sarwa,* which is said to be 926 feet above the sea, the surface is covered with a wide-spreading talus of boulders.

At the foot of the hills, close by, is a narrow margin of horizontal beds of sandstones and conglomerates, inside which again rise an older series of ranges formed of beds with a steep incline outwards, the dip being in places from 60° to 70°. Nothing can be conceived of as being more desolate than the aspect presented by these ridges, scarcely a sign of vegetation breaks the uniform brownness of the arid rocks. Entering the hills by the Siri pass,† four miles to the south of Saki-Sarwa, we find that the marginal zone above spoken of, has spread to a breadth of about four miles; the nearly horizontal beds of which it is composed completely covering up the highly inclined beds which appear near Saki-Sarwa. In the section exposed in the cliffs bounding this pass, a thickness of about 600 feet of beds of sandstone and conglomerate is seen. In places these dip to the south-east or east-south-east at an angle of 10°; and the disappearance of a bed of conglomerate at this angle accounts for the sudden and total extinction of a steady current of water which comes from the interior. Judging from the map, this seems to be the fate of most of the rivers along this frontier, few of them finding their way to the plains, although the continuation of the *nalahs* or dried-up water-courses indicates that they have done so formerly, or even may do so now under the exceptional circumstance of a heavy and long continued rainfall.‡

The gorge of the Siri pass is about four miles long. At its western entrance the horizontal beds are well seen resting on the highly inclined older rocks. Here a valley opens to view, in which, as far as the eye can reach to the north and south, numerous ridges, formed of green and red shales or clays and brownish sandstones, and further in, white limestones, crowd the space. All the beds dip outwards from the main axis of the Sulimán at considerable angles, none under 30°, and in places exceeding 70°. In the neighbourhood of Kadji,§ highly fossiliferous white nummulitic limestones of inconsiderable thickness, alternating with argillaceous beds, first make their appearance.

The open parts of this valley, though stony, support a certain amount of vegetation which is dwarfed and stunted in growth, but produces an agreeable appearance after the dreary waste outside.

Underneath the limestones occur some alum shales, and a succession of shales and sandstones. The ascent to the main axis of the Sulimán range traverses the up-turned edges of these beds.

* The tomb of Saki-Sarwa is a place of much resort both by Mahomedans and Hindus. A méla, which is held in the cold weather, attracts many thousands of pilgrims every year.

† An old kafila route to Kandahar.

‡ An instance of the latter case, indeed, has come to notice during the past few weeks since my visit; the floods which have caused the Indus to break into the old bed of the Sutlej and inundate the station of Omerkote having been principally due to the access of immense bodies of water from the lateral tributaries which drain the Sulimán range. The rainfall in Biluchistan has been quite exceptional in this monsoon, and the loss of cattle and the injury to houses has in consequence been considerable.

§ In this vicinity I found it quite impossible to fix my position, the courses of the rivers and low ranges represented on the Atlas-sheet maps pursuing purely imaginary directions.

From this the route lay south-south-west, through Chuti Mári, for fifteen or sixteen miles, the rocks, if we except some merely local rapid contortions, gently rolling as ripples do on the top of a great wave. The principal rocks in these higher regions (4,000 to 5,000 feet) consist of dark purple sandstones with highly ferruginous bands and occasionally badly preserved fossils. But there is one marked band of well preserved specimens of a species of *Ostrea*. These rest upon greenish and grey shales and occasional bands of a dark blue and very dense calcareous sandstones in which no fossils were apparent.

A bungalow erected by Captain Sandeman is situated on a partially isolated flat-topped hill about 5,880 feet above the sea and twenty miles south-south-west of Ek-Bai—the highest peak in this part of the range.

From the bungalow our route lay in a north-western direction, or nearly at right angles across the strike of the minor ranges to the west of the Sulimán. Passing down over the western slope of the main anticlinal, the dip of which is much more gentle than the eastern, we reached the Rakni valley, which is situated in a synclinal trough, the rocks on its western side rolling over again in an anticlinal and forming the Deka and Mazára hills.

The Rakni valley is a fine open flat plain, from five to six miles wide and 3,280 feet above the sea. It appears to be tolerably fertile, and is inhabited by a tribe called Hadianis.

In the pass to the north of the Deka hill a good section of the anticlinal is met with, the beds of shale and sandstone, a mile further on, disappearing beneath the nummulitic limestones, which latter—between this and Taghár, another fertile valley—form a synclinal trough. Between Taghár and the Karvada range, which bounds the Chamarlang valley on the east, there are a succession of valleys for the most part formed along the denuded axes of anticlinal rolls of the limestone. On the scarped side of the Harluk portion of the Karvada range the older rocks, sandstones and shales, re-appear underneath the limestones. And in these rocks, close to the western foot of the range, at about 800 feet below the base of the limestone, occurs the principal coal locality, where, associated with layers containing fossils of oysters and *turritellas*, occur two seams of coal; one of them averaging 2 inches, and the other about 9 inches in thickness. Other localities where this horizon was met with will be found mentioned further on. Time did not admit of my examining the Dadar and subsidiary ranges which bound the Chamarlang valley on the west. But so far as a distant view can justify an opinion, all these hills appeared to be formed of the lower rocks, with the reversed dip of the anticlinal; Dadar hill itself, which is 6,280 feet high, not appearing to have even a cap of the nummulitic limestone.

Our return route by the Hinki and Han passes afforded an opportunity of extending, very considerably, our observations on the geography* and geology of the country, as it traversed the ranges at a distance of from twenty to twenty-five miles south-west of our route out.

On the way to the Hinki valley, at the southern end of the Karvada range, a section of the coal-horizon rocks is disclosed. In a pass here, there are some thin layers of coaly matter in blue concretionary shales, the dip of which is 70° to south-south-east. A fault has brought the edges of these rocks into contact with the edges of the limestones. The Hinki valley runs along the denuded crest of an anticlinal roll of the latter rocks.

Between this and a fine open valley called Pasta Mara the lower rocks are in several places exposed. Beyond the latter place they extend for some distance to the north-west into the, for the most part, limestone area which lies between the Karvada and Ujh Hills.

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* Captain Lockwood, 3rd Punjab Cavalry, made a sketch survey of the country from which that portion of the accompanying map which lies west of the Sulimán range has been compiled. Most of the elevations given in this paper are from aneroid measurements by the same gentleman.

These lower rocks continue with several rolls until they slope up to the Jhandran range when a sharp anticlinal bend causes them to dip suddenly and disappear under the limestones of a marked range which bounds the Barkan valley, and of which an admirable section is exposed in the Han pass.

The eastern peak of Jhandran is about 1,200 feet above the valley. Vegetation is somewhat more abundant upon it than on the surrounding hills, and medicinal plants, which are reported to have special virtues, are found upon it. It was said that this hill had been the abode of a Fakir, some of whose domestic utensils had been turned into stone. Anticipating that some fossils of remarkable character might have given rise to the tradition, we ascended the hill, but our guides could not, or would not, shew us the cave in which these articles were said to occur.

Close under this peak there is a spring which yields a perennial supply of water. The banks of the river passing through the Han gorge are for the most part formed of a calcareous tufa, in which twigs, leaves, and recent land-shells abundantly occur. This deposit is similar to the well-known *Asarhar* of India. It does not appear to be in any way connected with the above-mentioned spring, which, if any, deposits but a very slight amount of calcareous matter.

The Barkan and a succession of valleys to the north-east present a fertile appearance, and there are several large and populous villages of the Khetrans situated in them. As their name implies, these people are cultivators;* but owing to the constant liability to attacks, cultivation is for the most part confined to the immediate vicinity of the walls of the villages. These valleys run with the strike of the limestones. To the east the ranges, of which Mazára is the principal peak, can at once be recognised as being formed of the older rocks both from their dark appearance and the different form of weathering which they present when compared with that of the ranges formed of limestones.

From this point our return to the Bungalow through the Rakni plain lay along the same route as on our outward march.

The rocks seen in the above sections are referable to several distinct formations as follows :—

	1.	RECENT	(*a*)	Alluvium, hill detrital beds, sand, and calcareous tufa.
Tertiary Period.	2.	PLIOCENE?	(*b*)	Sandstones and conglomerates.
	3.	MIOCENE?	(*c*)	Sandstones and clays.
	4.	EOCENE	(*d*)	Nummulitic limestones.
			(*e*)	Sandstones and shales.†

Recent (*a*).—Regarding the recent beds, in process of formation at present, but little of interest can be said. The alluvial area from year to year receives an increment from the inundation of the Indus and its tributaries. The drifting sand *dunes* constantly changing their positions creep along before the prevailing winds often, in their course, covering up and rendering useless cultivable land. The increase of the hill detrital and talus beds in this country of small rain-fall takes place but slowly. The travertin and calcareous deposits are forming in several places. In the Han pass there is, as already mentioned, a considerable exposure of this rock, but the sources from which it was derived are no longer in action.

Pliocene? (*b*).—In the absence of any fossil remains, it would be premature to attempt to refer the fringing beds of sandstones and conglomerates, which, as I have above pointed out,

* Derived from *Khet*, a field.

† Possibly some of these when more fossil evidence is collected will have to be referred to the secondary period (cretaceous).

are particularly well seen in the Siri pass, to any of the known groups which have been separated by their fossil fauna in other parts of the country. That these rocks will, when they come to be thoroughly examined, prove referable to the age of the Siwaliks is not only possible, but, from their position and associations, highly probable.

The facts observed regarding these rocks are, that in the Siri pass, where there is a good section exposed for a distance of about four miles, they consist of coarse sandstones, conglomerates, and boulder beds aggregating a total thickness of from 500 to 600 feet. In places they appear to be quite horizontal, but are for the most part inclined outwards, having a maximum dip of 10° to south-east and east-south-east. At the western end of the Siri pass they rest upon and against the inclined edges of the rocks next to be mentioned. Judging from the appearance of the map and of the country so far as it could be examined by a distant view, there is a greater breadth of these fringing rocks at the Siri pass than anywhere else in the neighbourhood. At Saki-Sarwa, for instance, the highly inclined lower rocks almost adjoin the plain without the intervention of more than a very narrow fringe. In the plains to the south-west of Saki-Sarwa, however, quite detached from the main mass of elevated ground, occurs a long range of low hills which from their amorphous structure will, I anticipate, prove to be formed of these beds.

On the west of the Sulimán range, in two localities, I met with conglomerate beds resembling in their lithological structure these rocks; the first, situated at the western base of the Deka hill, may very possibly be of this age; but the second, in Karer in the Luni Pathan's country, partakes so completely of the disturbance of the limestones upon which it rests, being included in a vertical synclinal fold, that I am forced to believe that it must belong to the age of the group of rocks next to be mentioned.

Miocene? (c).—As to the characters of the whole of this group I am not in a position to speak, since its higher members are covered up by the rocks above described in the Siri section. Much as I should like to have examined these rocks in detail, the season was not one in which it was possible to do so without considerable risk. The general appearance presented by them as viewed from a distance shews that they consist of dark brownish sandstones in beds of no great thickness, alternating with bright red, greenish and grey clays. They dip outward (east) to the plains at angles of from 30° to 70°, and strike with the main Sulimán axis, more or less north and south. I had no time to examine them for fossils, but it is probable that they will be found to correspond with one of the known groups of miocene or older pliocene age (Náhans?) of the Sub-Himalayas and Salt Range.

On this side of the Sulimáns they no doubt extend for a considerable distance, to judge from the distant view and the physical features indicated on the map I fully anticipate that the beds which are exposed near Saki-Sarwa will be found continuous with those known to occur much further north in the vicinity of Banu.* With the imperfect data I possess it is of course impossible for me to say whether this group is susceptible of sub-division or not. Fossil evidence, in the absence of internal unconformity, can alone decide this. The total thickness cannot, I believe, be under 3,000 feet and may be much more.

Eocene (d).—With the appearance of the nummulitic limestones we reach a geological horizon, as to the affinities of which there can be no doubt. Abounding in well preserved fossils and with well marked lithological characters, these rocks can be readily recognised wherever they occur.

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* See map to accompany Dr. Verchere's report on the geology of Kashmir, the Western Himalaya and Afghan Mountains. J. A. S. B., Vol. XXXVI, 1867.

In the east to west section across the country described in the preceding pages the limestones are first met with in the vicinity of Kadji, where they underlie, conformably, the sandstones and shales just described. Here there is but a small development of the calcareous element which is confined to a few small bands associated with shales and sandstones. This local alternation in the character of the beds when compared with the considerable unbroken thicknesses of limestones which occur in the sections further west, and which will be described below, suggest that this locality must have been situated near the margin of the sea in which the deposit took place, and was therefore more subject to the inroad of foreign materials than the areas in which the limestones are now found of great thickness and uniform character.

The fossils found at Kadji consist of *Pelecypoda*, *Gastropoda*, *Echinodermata*, and *Nummulites*, the species being identical with those found in the limestones of the western localities. *Echinodermata* appeared from my collections to be relatively somewhat more abundant in individuals at Kadji than they are in the west.

As to the thickness of these rocks here I cannot venture an opinion, but it appears to be very much less than it is in the west.

Crossing the anticlinal ridge of older rocks which forms the main axis of the hills, we first meet limestones again resting on the flanks of the reverse slope, where to the west of the Bungalow at Sandemanabad they occur as a narrow strip of buff-colored rocks containing nummulites and probably other fossils.

Further west, beyond the line of the Deka and Mazára hills, limestones are again met with, but here we seem to have reached the area of maximum-deposit, for we find thicknesses of from 1,000 to 2,000 feet with no breaks in the uniformity of their character save those caused by a few bands of nummulites which are densely compacted in a green silt. These bands are more strongly developed on the east side of the Taghár valley than elsewhere. There the tough limestones may be seen standing out from between the friable nummulitic beds. Nummulites are not, however, by any means confined exclusively to the latter beds, as they occur pretty generally throughout.

At Taghár, for some cause, the molluscous fossils were very badly preserved, being for the most part only in the form of internal casts, but of such there was a great abundance.

The section from the foot of Deka to the Karvada range, which bounds the Chamarlang valley, discloses only these rocks rolling in a succession of synclinal and anticlinal folds; except that towards the end of the Kerar valley there is a very sharp synclinal. which has caught up in its embrace a fold of conglomerate. This bed containing, as it does, fragments of the limestone, must be referred to a more recent period.

Underneath the limestones of the Karvada range, the older rocks, sandstones and shales with coal reappear.

The limestones here, as in all other places where the junction of the two groups of rocks is exposed on the side of a hill, form a marked cliff, the sandstones and shales forming the under-cliff. This cliff extends all along the Karvada range, and is from its top edge to the junction with the older rocks from 400 to 500 feet thick. The accompanying section represents the relations existing between the two groups in this part of the country.

In the Hinki valley, which is at the south-west end of the Karvada, the limestones are crossed by the return route. Between this and Pasta Mara they exhibit an unusual amount of local disturbance, in some cases the underlying shales and some ochreous beds appearing at the broken crests of the anticlinals. Between Pasta Mara and the Han pass the older rocks only are seen, but in the section at the latter place the limestones reappear in considerable thickness, dipping at low angles towards the Barkan valley. Not less than 1,200′ of these rocks is here exposed. Denudation has produced some very pretty effects in them. Isolated conical hills, several hundred feet high, standing out on the sloping flanks of the main range. From this eastwards the beds roll over, sloping up on the flanks of the Deka and Mazára range.

These limestones consist for the most part of soft friable beds of dirty white or very light fawn color. Sometimes, however, they are very dense or even sub-crystalline. From among the latter highly ornamental marbles might be selected. In these the sections of nummulites and other fossils present a very pretty appearance.

On the Karvada range boulders of a peculiar semi-crystalline limestone with green silt interspersed were met with, but the position of the bed from whence they came was not ascertained. The rock is dense and heavy, and at first looked like an igneous product.

In places veins of pure white lime, the result of the percolation of water, are of not uncommon occurrence.

Layers and nests of gypsum, too, are sometimes met with. Some long sticks of fibrous gypsum (selenite) were obtained in the Hinki valley.

Fossils in these limestones were abundant wherever searched for. The collection brought to Calcutta includes perhaps a hundred different species. The places where I obtained these were in the Taghár valley, Chukerani, Pasta Mara, Kadji, Karvada, and the Barkan valley. Besides these I received a number from Captain Sandeman from the Shum plain, which is situated some miles south of Saki-Sarwa.

The following is a preliminary list of the species which were obtained :—

NUMMULITES.

Probably several species, not yet determined.

CORALS.

Pachyseris Murchisoni, J. Haime
Monivaultia ?
A branching coral, not yet determined.

ECHINODERMATA.

Cidaris Verneuili, d'Arch.
Phymosoma nummuliticum, d'Arch.
Conoclypeus Flemingi, d'Arch.
Schizaster Newboldi, d'Arch.
„ *Belouchistanensis*, d'Arch.
Brissopsis Sowerbyi, d'Arch.
„ Sp. ?
Besides several other species which remain to be determined.

PELECYPODA.

Teredo Sp. ?
Crassatella Sindensis, d'Arch.
„ Sp. ?
Corbula subexarata, d'Arch.
Lucina gigantea, Desh.
„ *subvicaryi*, d'Arch.
„ several other species.
Astarte Sp. ?

Venus subvirgata, d'Orb.
„ *astarteoides*, d'Arch.
„ *subovalis*, d'Arch.
„ *subeveresti*, d'Arch.
„ *Hyderabadensis*, d'Arch.
Cardita Beaumonti ? d'Arch.
„ several other species.
Cardium Homeri, d'Arch.
„ several other species.
Cypricardia Vicaryi, d'Arch.
Arca Kurrachensis, d'Arch.

Chama Sp. ?
Mytilus subcarinatus, Desh. ? ?
„ several other species.

GASTEROPODA.

Nerita Sp. ?
Natica sigaretina, Desh. ?

Trochus,
Turbo,
Phasianella,
Turritella, } One or more species of each of these genera. These have not yet been determined.
Cerithium,
Fusus,
Cassis,
Cypræa,
Ovula Depressa, d'Arch.

Eocene (*e*).—Underneath the nummulitic limestones occur a series of rocks which differ from them very much in their lithological characters, and to no inconsiderable extent, too, apparently, in their fossil contents.

But these rocks, so far as is known, contain no fossils whose occurrence would be inconsistent with their being referred to the tertiary period, and it would appear that lithologically similar rocks have been met with elsewhere underlying the limestones, and which have been considered to belong to the nummulitic series. Adopting this view (with the understanding that some of the lower portion of this succession in which my very cursory examination did not result in the discovery of *any* fossils may hereafter yield evidence of their belonging to the cretaceous or some older formation) I shall proceed to describe the sections as I saw them.

Underneath the limestones which, as I have above said, occur at Kadji, there appear some earthy alum shales followed by sandstones and shales. These beds dip at angles as high as 70° away from the main axis of the Sulimán. After crossing some hundreds of feet in thickness of the upturned edges of these rocks, badly preserved fossils commence to show themselves in the sandstones, and fragments of a thin layer of densely compacted oysters are met with scattered over the surface of the ascent. Associated with this layer are some shales, and it is probably on this horizon some few miles to the north of Kadji that the coal mentioned on p. 146 occurs. I started one evening to visit this coal, but my guide so managed matters that we never reached our destination. The following day I was dissuaded from my intention of proceeding to it in the sun, as a long ride lay before us, and it was represented to me that exposure in these hot valleys could not be undertaken without risk at this season. The opinions on this coal given on page 146, and the universal testimony of the natives, unite in saying that it is in extremely small quantities. And the handful of fragments of lignite brought by a special messenger fully testified to the worthlessness of the deposit. In a geological point of view, these traces of carbonaceous matter, together with the accompanying fossils, are not without interest, as they confirm the views of the geological structure arrived at by examination of the physical relations of the beds.

Crossing over a considerable thickness of these sandstones and shales the road leads over the Han-ki-der, a peak which is situated due south of the lofty Ek-Bai. This peak, as also in all probability Ek-Bai, are formed of dense white sandstones, under which there is seen in a deeply cut valley close by, a considerable thickness of green shales, so that if we except these shales, it is the lowest rocks of the geological succession which form the highest points of the range. From this point the edges of the rock turn over, and it becomes apparent that the main axis of the range is formed by a huge anticlinal roll, along the crest of which there appears to have been a fault by means of which, the upthrow being to the east, the turned over edges of the white sandstones are opposed to those of the upper beds.

I have already on page 148 described the characters of the rocks seen between Han-ki-der and the Bungalow, and as the other intervening sections are few and unimportant, I shall pass at once to those in the Chamarlang valley where the coal occurs.

The first coal seen is exposed on the scarped side of a hill called Kuch-búdi. The section is as follows; the thicknesses of the shales were estimated, not actually measured. Ascending—

1.	Coal, dip 10° W.	2″	10.	Shale	?
2.	Gypseous shales much jointed	25′·0″	11.	*Coal*	4½
3.	*Coal*	2″	12.	Parting	2″
4.	Same as 2	10′·0″	13.	*Coal*	2″
5.	*Coal*	4″	14.	Shale	5′·0″
6.	Shales	25′·0″	15.	*Coal*	2″
7.	*Coal*	3″	16.	Shale	10′·0
8.	Parting	4″	17.	*Coal*	2″
9.	*Coal*	2″	18.	Shale with oyster layer.	

The hill is capped with sandstones which contain fossils of *Turritellae*.

In this section then there is about a total of 2 feet of coal, which is distributed in nine thin layers throughout a thickness of certainly not less than 100 feet of shale.

In another section of the same hill, three seams, possibly identical with some of the foregoing, locally swell out in places, but do not average more than 2 inches in thickness.

Passing from this hill up a small valley in a westernly direction we meet another section at the end of the Harluk portion of the Karvada range, the geological horizon being precisely identical with that of the foregoing.

Here there are in all about seven seams, the thickest of which does not exceed 6 inches. The dip is much disturbed.

The next locality is in the continuation of the same beds on the western or scarped side of the Karvada range, where it overhangs the open valley of Chamarlang.

It was at this locality that the appearances seemed to justify the hope that coal in workable quantity would be found. The following is the section of rocks exposed in this range in ascending order :—

Blue and green clay shales.
Sandstones with fossils of *Turritella.*
Shales.
Coal, good, averaging 9 inches in thickness, strike N.-E. S.-W.; dip 30° S.-E.
Shales with strings of *coal.*
Oyster bed.
Sandstone with badly preserved fossils.
Green shales.
Sandstones.
Red clay shales.

Limestones about 400 feet thick to the crest: below the crest, on the eastern slope, about 300 feet more seen.

The same section appeared to be pretty constant along the hill side for a considerable distance, the coal continuing for upwards of a mile at least. As to the character of the coal I shall again speak further on.

The next and last section in which traces of coal were found to occur is in a pass at the south-west end of the Karvada range and which leads into the Hinki valley; here some thin layers of papery coal were observed in the bluish green shales, which at this spot are much disturbed, dipping from 70° (to south-south-east and south) up to the vertical; further on, their edges are brought in contact with the limestones by a sloping fault.

Between Hinki and Pasta Mara the lower rocks occasionally crop out under the broken crests of the anticlinal rolls of the limestones. Beyond Pasta Mara again these rocks appear, as has also already been mentioned, and finally rise to form the Jhandran range. The route between these places crosses through one short gorge not 300 yards long, which is cut at right angles through an anticlinal roll of dense calcareous sandstones, probably the same as some seen on the main axis near Chuti Mári. A sudden bend to the east carries these beds under the limestones of the Barkan valley.

Fossils.—The evidence afforded by the fossils which I was able to collect as to the age of these rocks is unfortunately somewhat meagre.

I found no trace of any cephalopods whatever, and some could hardly fail to exist if the rocks are either cretaceous or jurassic.

Both Dr. Verchere and Captain Vicary described somewhat similar rocks; the former in the north of the Sulimáns, and the latter in the south. It hardly comes within the range of this account however, as I have already said, to attempt to closely correlate these rocks with others observed elsewhere.

The following is a list of the fossils which for the most part have only as yet been generically determined:—

PELECYPODA.

Ostrea multicosta, Desh.
O. Flemingi, d'Arch.
O. callifera, Lam. ?

GASTROPODA.

Nerita.
Natica.
Solarium.
Turritella angulata, J. de C. Sow. ?
Cerithium.
Rostellaria Noorpoorensis, d'Arch. ?

Some nummulites also occur in the upper beds of sandstones; and a monocotyledonous aquatic plant was obtained in the shales of the coal horizon in the Deka valley.

ON THE COAL AND ITS ECONOMIC VALUE.

From the foregoing it will appear that the best seam of coal which has been discovered in these hills is only 9 inches thick. This seam is continuous for upwards of a mile just inside a low run of hills flanking the Karvada range, which borders the Chamarlang valley on the south-east.

The subjoined assay by Mr. Hughes, of the Geological Survey, of a specimen of coal from the seam shows that, if found in quantity, it would afford an extremely valuable fuel. It may be described as a light non-coking coal. In the absence of all trace of vegetable structure, it would perhaps be incorrect to speak of it as a lignite.

"The mean of two assays give loss by drying, 6·7 per cent. (=water).

Carbon	57·8	Does not coke even when rapidly heated.
Volatile	38·8	
Ash	3·4	
TOTAL ...	100·0	

Ash flocculent, reddish in colour."

Another sample, taken as it came, that is to say, without the removal of the yellow clay which has infiltrated between the cracks and joints in the coal, gave the following result; from which it will be seen the proportion of water is somewhat greater, and that the percentages of carbon and ash exceed those in the preceding, but the result is still good:—

Loss by drying, 8 per cent. (=water).

Carbon	59·2
Volatile	35·8
Ash	5 2
TOTAL ...	100·2

In my preliminary report I pointed out that, notwithstanding the excellent quality of the coal, a seam of only 9 inches is practically valueless.

Were the seam situated near to any line of traffic, some hundreds of tons could without doubt be extracted from near the surface at a small cost. But, however situated as regards traffic, it is a perfectly obvious fact that such a seam could not be worked to the deep with profit.

It remains then to discuss the prospect of better seams being hereafter discovered. In favor of this prospect the only thing that can be urged is, that since a period did exist during the deposition of these rocks when vegetable matter was accumulated in sufficient quantities to form layers of coal, it *may* have happened that in some places the vegetable growth was exceptionally active, or the period exceptionally prolonged, and, as a consequence, the fossilized vegetable matter or coal was formed in exceptional quantities.

On the other hand, as rendering it improbable that such a thick deposit will ever be found, three arguments may be enumerated:—

1stly.—The experience of all those who have explored, or attempted to work, the coal of the same geological age in Sind and the Punjab is against the probability of coal existing in large quantity.

2ndly.—The country in question has, under Captain Sandeman's orders, been thoroughly searched, and all parts are well known to the different tribes, yet no coal forming a thick seam has been discovered. The slight coaly indications, which have in some places been observed and pointed out by the Biluchis, testify to the intelligence and care with which they have hunted over the ground.

3rdly.—My own examination of the ground has shown that the geological structure warrants the belief that since we have rocks of precisely the same age on the outer or eastern slope of the Sulimán range as those with which the coal is associated in the Chamarlang valley, the prospect of finding coal at the former locality should be as good as it is at the latter; and not only as good primarily, but from the high inclination of the beds, their edges being all exposed, very much better. At the same time these outer ranges being readily accessible to the people of the plains, many of whom, besides the chiefs, have some idea of the value of coal, it seems reasonable to conclude that did a large seam occur, it would long ere this have been brought to light. I have above described the character of such coaly indications as have been discovered east of the main range, and have pointed out how unimportant they are.

Had the Chamarlang valley been the only locality examined, it might possibly have been concluded that boring would be advisable to prove the lower rocks; but as these lower rocks are elsewhere exposed and have yielded no trace of a seam, it may be stated that boring could only involve an almost certain waste of money.*

For the benefit of non-geological readers, I shall allude here to a theory which was mooted in reference to the Lagari coal in the early correspondence, and which theory I have known also to be applied to inferior or small deposits of coal of very much greater age than it. This theory is that the coal is not abundant, or is of inferior quality, because it is only "in process of formation." Geological chronology is not yet so far settled as to enable us to say how many thousands or millions of years have elapsed since the coal became coal; but this we can positively assert, that since that time the only possible change that can have taken place is in the wrong direction, in other words, the abstraction or removal of the combustible portions. Nothing short of a miracle, and miracles find no place in the operations of nature, could convert the substances in contact with the coal, be they silicious, calcareous, or aluminous, into carbon or bitumen.

SULPHUR.—While in the hills I heard of a deposit of sulphur which occurs in the Soree pass; subsequently Captain Sandeman obtained some specimens of the crude ore and the manufactured sulphur. The former proves to be gypsum, which is much penetrated by strings of sulphur. This deposit, if not the result of more direct volcanic action, has probably been derived from a hot spring, recent or extinct. A hot spring at Pir Zinda in the Soree pass not far from where the sulphur was brought is well known and is a place of much resort.

Close by is a hill called Bindar, which, according to the map, is 2,858 feet high, and stands out prominently above the low ranges. The season was unfavorable to my examining that part of the country as I should otherwise have done. If this hill should prove to be an

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* I put this somewhat more strongly than in my original report, as since it was written, I had, on the return march, an opportunity of examining the lower rocks more closely.

ancient volcano, the occurrence of the sulphur will find an easy explanation. A visit to the hill in the cold weather would be well worth the trouble of any one who might have the opportunity of going there. Sulphur is manufactured from this ore by the Bozdars and Kusranis, and is stated to be abundant. The process is most simple. An earthen gurrah (a thin spherical pitcher) filled with the ore is placed on the fire; as soon as sublimation begins to take place the fumes are caught in a second gurrah, which is placed mouth downwards on the first; cakes of pure sulphur of more or less crystalline structure are thus produced.

To the south of the country visited by me petroleum is reported to occur in the Mari hills. It is collected and used by the Biluchis principally for external application to the sores of diseased cattle. I have no information as to its abundance.

Some rather indefinite rumours of brine springs, and one of the occurrence of actual rock salt, reached my ears; but I cannot vouch for the truth of the statements.

These, as well as many other subjects, will receive no doubt full attention when the systematic examination of the country is taken up by the Geological Survey.

NOTE OF THE PROGRESS OF GEOLOGICAL INVESTIGATION IN THE GODÁVARI DISTRICT, MADRAS PRESIDENCY, *by* WILLIAM KING, B. A., *Deputy Superintendent (for Madras), Geological Survey of India.*

So far, the Godávari District is one of the most interesting in Southern India, from the number and variety of its rock-series: these being found to represent periods in the palæozoic, secondary, tertiary and recent formations.

Since 1837, the district has been rendered classic through the researches of Dr. Benza, (guided by General, then Colonel Cullen), and the Reverend S. Hislop (assisted by Lieutenant, now Colonel Stoddard, Madras Engineers): the first of whom showed that a band of limestones with marine and estuarine exuviæ occurred interbedded with trap in the low hills of Pángadi; while in 1855 and 1859 the latter announced that a narrow but broken band of the Deccan traps with intertrappean limestone containing lower eocene remains cropped out not far from either bank of the Godávari above the town of Rájahmándri.

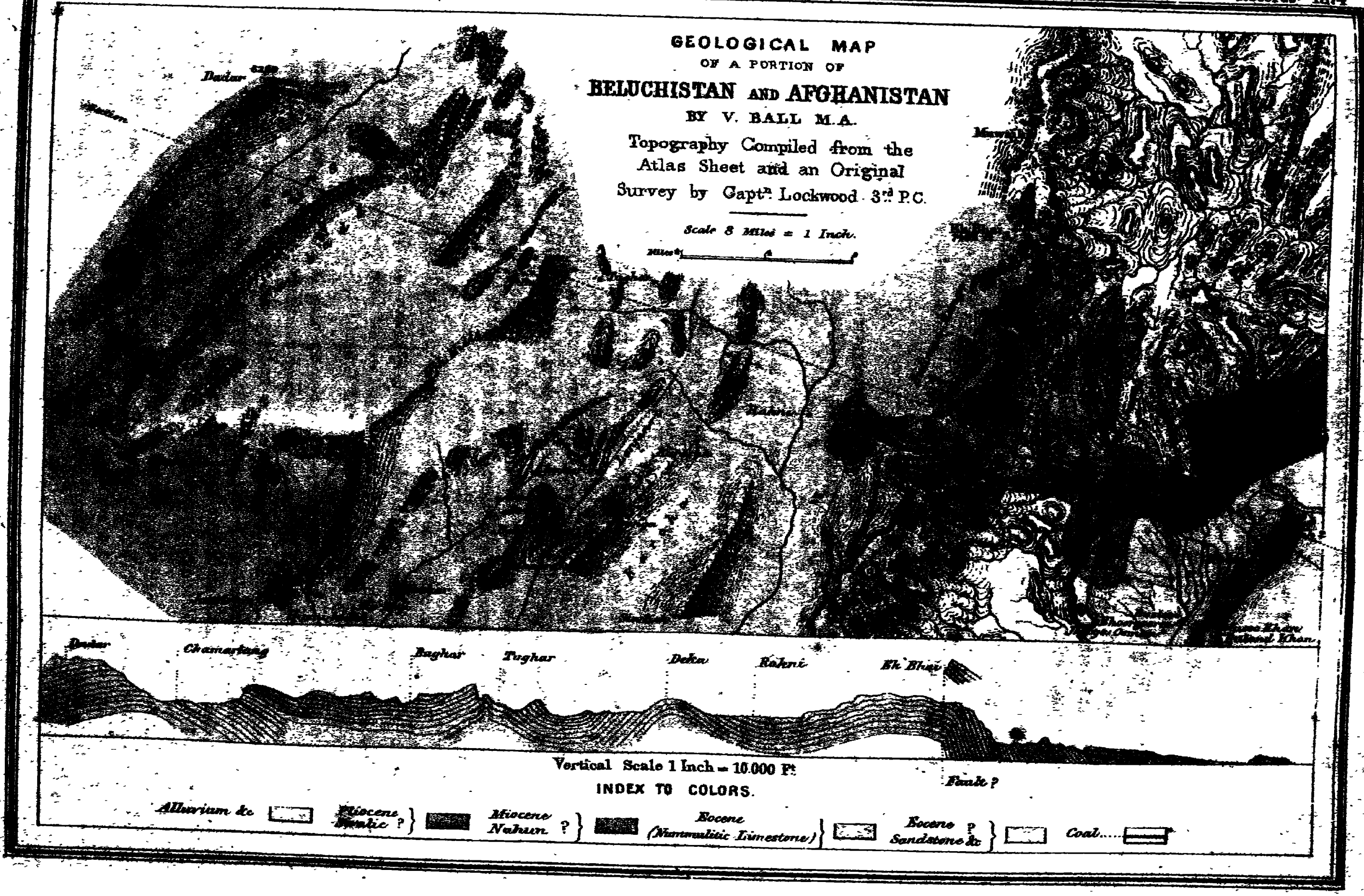
The later investigations of the Geological Survey have added considerably to the above knowledge; announcements of these additions by Mr. W. T. Blanford and myself having been given from time to time in these Records.

Taking the several groups of rocks in descending order, there are :—

1. RECENT DEPOSITS, including the long-known alluvial accumulations of the Godávari and Kistnah which merge into one another and form the wide and extended belt of low-lying plains edging this part of the Bay of Bengal.

2. CUDDALORE SANDSTONES :—These rise up with an easy slope to the westward from under the alluvium as the low plateaus of Samulcottah, Dowlaishwarum, Pángadi, Chinna Tripetty, and Golapilly, and are here and there capped with laterite. The series appears to be identical with a like set of rocks occurring at Cuddalore, the Red Hills near Madras, and again at Nellore, and more or less continuous between these places. They were named Cuddalore sandstones by Mr. H. F. Blanford in 1857.

3. DECCAN TRAP with INTERTRAPPEANS crop out from under the Rájahmándri sandstones at Kártéru and Pángadi; and as Hislop has shown, the intertrappean limestone is of lower eocene age. A few additional genera and species to those already described have been obtained by Mr. A. J. Stuart, Sub-Collector of the Godávari, from the Kártéru locality, my own being more particularly from near Pángadi.


GEOLOGICAL MAP
OF A PORTION OF
BELUCHISTAN AND AFGHANISTAN
BY V. BALL M.A.
Topography Compiled from the
Atlas Sheet and an Original
Survey by Captn. Lockwood 3rd P.C.
Scale 8 Miles = 1 Inch.
Dadar
Chamarlang
Baghar
Toghar
Deka
Rahni
Kh'Bhai
Fault ?
Vertical Scale 1 Inch = 10.000 Ft
INDEX TO COLORS.
Alluvium &c
Miocene Manchar ?
Miocene Nahun ?
Eocene (Nummulitic Limestone)
Eocene ? Sandstone &c
Coal

4. LAMETAS or INFRATRAPPEANS.—While working out the preceding series in the Pángadi plateau, I discovered a new set of rocks immediately underlying the lower flow of trap a short distance south of the village of Doodkooroo, which is likewise traceable to Gowreepatnam, a mile or so further east. The chabootra, or resting place, of Doodkooroo and the old pagoda of the second village are built of blocks from a fossiliferous bed of this group, which is so crowded with a species of *Turritella* that it may be called in the series the Turritella Zone. This shell is very closely allied to, if not actually identical with, *T. (Torcula) dispassa* of Stoliczka (Cretaceous Fauna of Southern India, Palæon. Indica). The other associated fossils are *Nautilus, Rostellaria, Murex, Fasciolaria, Latirus? Pyrula, Fusus, Pseudoliva, Pleurotoma, Volutilithes* (very near *Voluta torulosa,* Desh.), *Natica, Turritella* (near *T. Pondicherriensis*, Forbes, and *T. Multistriata*, Reuss.), *Cerithium,* and *Dentalium. Ostrea, Cucullea, Pectunculus, Corbis, Cardita (C. variabilis,* Hisl. and others), and *Cytherea.* There are also a *Ciliopod (Lunulites)* and numerous *chelæ* of a small crab. Only one of these forms, *Cardita variabilis,* is common to this zone and the intertrappeans. There is evidence, I think, to show that the bottom trap of Pángadi is lying unconformably on the Turritella band. Lithologically, this group is very similar to the Lametas in other parts of India.

5. RAJMAHALS.—These dark-red and brown ferruginous sandstones and conglomerates with a zone of fine white and buff shales containing *Ammonites, Pecten, Nucula, &c.,* with *Palæozamia, Cycadites, &c.,* crop out from under the Lametas near Daywarrapilli. In addition to the above and another set of fossils from Innaparazpolliam, which Dr. Stoliczka, just before leaving on the Yarkand expedition, pronounced as having their equivalents in the *Oomia* beds of Kachh (uppermost jurassic strata), I have, during the last season, obtained a good series of plant remains from the Golapilly plateau some twelve miles west of Ellore. They are *Pterophyllum Hislopianum, Palæozamia acutifolium, Pal. rigida, Pecopteris Indica, P. ? lobata, Taxodites ?, Lycopodium ?, Auracarites ?,* seeds, leaf-stalks, and stems.

6. DAMÚDAS.—a. *Kamthis.* A further examination of the fossil-locality near Kunlacheroo (pointed out by W. T. Blanford in a previous number of the Records) enabled me to secure the following:—*Vertebraria, Glossopteris Browneana,* var. *Indica,* and var? *Australacia, G. musæfolia ?, Næggerathia, Filicites, Phyllotheca Indica, Yuccites ?,* and stems.

b. *Barakars.*—The opinion already given by me in Vols. V and VI of the Records that the sandstones of Béddadanole are of this group, and that they probably contained coal, has been confirmed by the borings selected for Mr. Vanstaveren, the Executive Engineer. Four seams of coal and carbonaceous shale were struck, only one of which is, however, of any thickness. The bore hole of this is near the eastern edge of the field; and at 188 feet 4 inches, a 4½ feet seam of poor coal was found. My colleague Mr. Tween gives the following assay:—

Coal.			*Coke.*		
Carbon	... ...	16·4	Carbon	... ...	22·5
Volatile	... ...	30·6			
Ash	... ...	53·0	Ash	... ...	77·5
		100·0			100·0

This was evidently from a fair average of the material brought up from the hole, which was more black shale than anything else; for a subsequent analysis, of fragments of fair coal picked from the stuff, gives—

Coal.			*Coke.*		
Carbon	... ...	37·0	Carbon	... ...	59·5
Volatile	... ...	37·8			
Ash	... ...	25·2	Ash	... ...	40·5
		100·0			100·0

Percentage of moisture, 12·8.

As the borings are continued in these and in upper strata, better results as to quantity and quality may be obtained.

There is no other exposure of *coal measures* in this district; neither, from my latest examination, which was carried on to Bezwadah and thence westward to within range of the old work of Messrs. Charles, Æ. Oldham, and R. B. Foote, is there any indication of further outliers in the Kistnah District.

7. CRYSTALLINES.—The gneiss of the Godávari district and down to Bezwadah is to a great extent a highly garnetiferous quartzofelspathic variety, well bedded and foliated. It often weathers into a rock scarcely distinguishable from a sandstone. Bands of very quartzose rock with *graphite* sparingly distributed through it occurs close to Bezwadah, as also some beds of crystalline limestone highly charged with *pyroxene*. Traces of *graphite* are found in the streams of the Béddadanole field, which have evidently been brought down from the gneiss country to the north. Large masses of *tourmaline* of very black color occur at times in the gneiss; and from one region in the Yernagoodum taluq near Koyegoodum pieces of the same mineral have over and over again been sent to me by the district officials* as coal.

The area of crystallines has, however, only been cursorily examined as to its details, and it is therefore premature as yet to refer to it except in this short manner.

NOTES UPON THE SUBSIDIARY MATERIALS FOR ARTIFICIAL FUEL, *by* THEODORE W. H. HUGHES, A. R. S. M., C. E., F. G. S., *Geological Survey of India*.

The manufacture of artificial or brick fuel from small coal and dust, which is becoming an important industry in Europe and America, has a very practical bearing upon the development of the coal resources of this country, owing, not to any pressing necessity to utilise the waste which is gradually accumulating in our chief centres of mining, but to the fact that much of our coal is exceedingly soft and liable to disintegrate, whilst some of it is so crushed in its original bed that it can only be brought to the surface in the form of dust.

It is already apparent that the final remedy for the waste of dust-coal will be the direct one of burning it in a state of powder. The advantages of perfect combustion lately obtained in this way by Mr. Crampton are so important that it may yet prove economical even to crush round coal for the furnace. At present, however, in India, where the chief demand is for locomotive engines, only two plans are open to us to render dust-coal of marketable value; the one to coke it; the other to convert it into artificial fuel. The system which promises least success is that of coking, for the excess of ash and water in some, and the small amount of volatile matter in others, affect the coking property of a large percentage of Indian coals, and the most generally applicable method for their utilisation is that of consolidating them as artificial fuel. It may therefore be useful to bring to notice a very interesting and valuable essay, *De l' Agglomération des Combustibles*, by M. A. Habets, of the École des Mines de Liége, in which the substances are indicated that have found most favor in France and Belgium, where the manufacture of brick-coal has attained its greatest development.

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* Some years ago, when arranging the collection in the Madras Museum, I found a piece of tourmaline labelled as coal, and as forwarded by the late Mr. Boswell, M. C. S., who was one of the advocates for the occurrence of coal in the Kistnah District.—W. K.

The principal qualities to be aimed at or avoided in the substances used are:—

1st.—To supply any defect in the combustibility of the raw material.

2nd.—To prevent the fuel from crumbling in the fire.

3rd.—Not to augment the quantity of inorganic matter in the mass.

Tar and, above all, pitch are the matters best adapted to fulfil all these conditions.

The principal substances proposed, or that have been the subject of experiments, are as follows:—

1st.—Vegetable and mineral tars, fluid and dry pitch, asphalt, bitumen, resin, and gutta-percha.

2nd.—Amylaceous substances, damaged starch and farinaceous matter, residues from the manufacture of starch, &c.

3rd.—Fatty matter, animal or vegetable, oil-cake (colza, poppy, &c.).

4th.—Gelatinous matter, gelatine, glue, débris of horns, dung, &c.

5th.—Mucilaginous matter, certain decomposed mosses, &c.

6th.—Potash or soda soaps.

7th.—Oxygenous substances, such as nitrate of soda, chlorate of potash, and peroxide of manganese.

8th.—Earthy plastic substances, clay, plaster, lime, tarry cement, and silicate of soda.

Inorganic substances.—The inorganic matters comprised under the two last headings are evidently only applicable for the manufacture of fuel for domestic purposes, where the object is to sustain combustion for a long time without letting the heat be too strong. M. Habets leaves it to be inferred that the oxygenous substances are added to modify in this case the purely deadening influence of the incombustible earths, which form as much as 25 per cent. of the compound.

Amylaceous substances.—After tar and pitch, starchy matters are those which have been most frequently used. In fuel for domestic consumption they have replaced tar, on account of the inconvenience arising from the odour of the latter material. With a proper draught, however, no annoyance at all is felt.

Tar.—Tar, which is still employed to a certain extent in England, has almost entirely fallen into disuse in Belgium, and is only retained in a few French factories, it having been found that bricks made with tar will not bear long carriage, that they stick together when placed in heaps, and that they give off in burning a great deal of smoke and a disagreeable smell.

Fluid pitch.—The manufacture with fluid pitch, which in 1858 had made rapid progress, is now (1871) only carried on in two factories in Belgium, namely, at Sauwartan—where Knab's system of coking furnishes the necessary pitch—and at Gosselies, where the employment of Evrard's machinery necessitates its use. The plant required for the application of fluid pitch is much larger and more difficult to keep in repair than that required for dry pitch. Heaters, pumps, tubes, mixing screws, and special distributers, &c., must be provided; skilled workmen must be employed, and the drawback arising from imperfect distillation in the drying process must be guarded against, otherwise the bricks will be too smoky and melt in the sun.

Dry pitch.—Dry pitch has almost universally superseded fluid pitch, for experience has shown that less machinery is required to work it with, a more regular product is obtained, and the bricks are less liable to soften. Its employment permits a certain degree of automatism, which has had the most happy result in the lowering of the cost, owing to the doing away with the necessity of having specially educated workmen; and another great advantage lies in the fact that the bricks can be handled almost immediately after leaving the press.

Dry pitch is not a constant product. According as the distillation has been pushed too far, or the contrary, its density varies between 1·286 and 1·275. If the evaporation is carried on to dryness, a product is obtained deficient in agglutinating properties, and it is found necessary to add fluid pitch, tar or some heavy oils. The following is an analysis of dry pitch of 1·28 density:—

Carbon	75·32
Hydrogen	8·19
Oxygen	16·06
Ash	·43
	100·00

The above extracts will suffice to show that M. Habets is an advocate for dry pitch as an agglutinating material; and the experience gained in Belgium and the north of France certainly points to it as best adapted for the purpose. But he points out that this process has not been adopted in the south of France, owing to the heat of summer making it difficult to reduce the dry pitch to the state of powder; and until this difficulty is surmounted, the same objection would hold with even greater force for India. In the southern provinces of France the soft-pitch process prevails, smoke-consumers being adapted to the furnaces to obviate the evil effects of the mass of volatile products: the same system could probably be applied to the case of India. It was no doubt considerations of this nature that led Mr. Danvers in his book on coal to elect in favor of the starchy cements for India; and at present the choice seems to lie between these and the soft-pitch process.

M. Habets makes little or no specific mention of the other substances enumerated in the 3rd, 4th, and 5th sections of his list. We may presume that no practical result was obtained from them. His essay is most valuable for the detailed descriptions and figures of the different processes of manufacture.

Some attempts have been made to adapt farinaceous agglutinants to the semi-bituminous waste of our collieries in the Ráníganj field; and considered as mere experiments they were successful, but commercially they were failures. Rice and Indian-corn were both tried, and they formed good cements, but they constituted a very heavy item in the cost of production.

I think the time has scarcely arrived for the manufacture of artificial fuel to be a successful industry in the Ráníganj field while whole coal can be procured at its present or even at a considerably enhanced price; but with regard to the Dárjíling coals (which can only be extracted as dust), and to a certain extent those of the Wardha valley, the only course left for utilising them in the absence of the possibility of converting them into coke is to make them into brick-coal.*

Some trials have recently been made in the Central Provinces to consolidate the coal of the Warora colliery—which is of a very friable nature—by means of rice and gum, &c. The proportions of the substances used were—

Coal	112 lbs.
Rice	1 lb.
Gum	½ lb.
Water	½ gallon.
Nitrate of soda	4 grains.
Potash	4 "

* My colleague, Mr. Mallet, was the first to suggest that the Dárjíling coal, in order to be rendered available, ought to be made into patent-fuel.

The fuel so prepared was tried at the mint, but it burnt in a dull, smouldering manner, gave a bad welding-heat, and left a great deal of clinker. An assay proved it to contain 10·2 per cent. of water and 22·6 per cent. of ash—an amount of useless matter that could not fail to retard combustion.

As a highly oxygenous substance, it might have been supposed that the addition of nitrate of soda would assist combustion, but any advantage that the presence of this salt ought theoretically to confer would be neutralised by the heat lost in evaporating the water that it absorbs readily from the atmosphere. Four grains are scarcely an appreciable quantity, and would yield only enough oxygen to enter into combination with less than one grain of carbon.* To be of any theoretical value, it must be used in larger proportion than that given above. But the use of nitrate of soda is, I think, questionable, on the ground of its deliquescent nature, unless a plan of rendering each lump of fuel thoroughly water-proof can be adopted. It must also affect the formation of clinker.

Gum, which is one of the ingredients, has never been brought into practical use in Europe owing to its price, and the same circumstance will probably militate against its employment in this country.

When a farinaceous cement is employed, it is usual to add some alum in order to strengthen it. The Diamond Fuel Company, which is now working Barker's process, use sulphate of alumina or chloride of alumina in hydro-chloric acid, in the proportion of one ounce to a gallon of solution of starch. Tar, or better still pitch in small proportion, is also added in a small proportion to render the fuel less friable and more water-proof. In the case of the Warora fuel, neither alum nor pitch was used.

The Dárjíling dust coals approach in composition those of anthracitic regions, and will require a cement that does not consume in the fire more rapidily than the coal, for it has been found that "if the agglutinating material burns too briskly, the particles of coal having lost their adhesive coating crumble in the fire and fall through the grate unconsumed."* Some slow-burning farinaceous cement will probably be the best substance. On the subject of Dárjíling coal, however, I refer the reader to the detailed report of Mr. Mallet, in the Memoirs of the Geological Survey, Vol. XI, which is now in the press.

Attempts have been made to coke mixtures of anthracite and bituminous coal-dust, but the coke produced could not bear handling; it had no density, and it was very porous, owing to the fact that the particles of anthracite would not unite with the bituminous particles.

Putting clay aside as an agglutinating material for the reason which has already been given, the most easily procurable cement in this country is that coming under the head of starch; but tar or its derivatives possess properties which render them almost a necessary ingredient in most artificial fuels.

There is not a large native supply of pitch, but the Bengal Coal Company are carrying out experiments in a most spirited way to prove the yields of tar, pitch, oils, &c., from their different coals; and the results will give useful data by which to estimate the capability of Indian coals as a source of supply.

CALCUTTA, *1st October* 1874.

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* The "Journal of the Franklin Institute," 1874, Vol. LXVII, p. 118.

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GOVERNMENT OF INDIA.

Journal de Conchyliologie, 3rd Series, Vols. XI to XIV, Nos. 1—3, (1871—74), 8vo., Paris.

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THE ACADEMY.

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THE SILESIAN SOCIETY.

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BRISTOL.—Proceedings of the Bristol Naturalists' Society, New Series, Vol. I, pt. 1, (1874), 8vo., Bristol.

THE SOCIETY.

CALCUTTA.—Journal of the Asiatic Society of Bengal, New Series, Vol. XLIII, pt. I, No. 2, (1874), 8vo., Calcutta.

THE SOCIETY.

„ Proceedings of the Asiatic Society of Bengal, Nos. VI and VII, (1874), 8vo., Calcutta.

DITTO.

CAMBRIDGE, MASS.—Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. III, Nos. 5 and 6, (1872), 8vo., Cambridge.

MUSEUM OF COMPARATIVE ZOOLOGY.

„ Illustrated catalogue of the Museum of Comparative Zoology at Harvard College, Nos. VII and VIII, (1873), 4to., Cambridge.

DITTO.

DRESDEN.—Sitzungsberichte der naturwissenschaftlichen Gesellschaft Isis in Dresden, Jahrg., 1873, April—December, (1874), 8vo., Dresden.

THE ISIS SOCIETY.

EDINBURGH.—Transactions of the Royal Society of Edinburgh, Vol. XXVII, pt. 1, (1872-73), 4to., Edinburgh.

THE SOCIETY.

„ Proceedings of the Royal Society of Edinburgh, Vol. VIII, No. 85, (1872-73), 8vo., Edinburgh.

DITTO.

FLORENCE.—Memoire per servire alla descrizione della Carta Geologica d'Italia, Vol. II, pt. 2, (1874), 4to., Florence.

GEOLOGICAL COMMISSION OF ITALY.

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles, 2nd Series, Vol. XIII, No. 72, (1874), 8vo., Lausanne.

THE VAUDOIS SOCIETY.

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THE ASSOCIATION.

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THE SOCIETY.

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THE INSTITUTE.

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THE SOCIETY.

" Proceedings of the Royal Society of London, Vol. XXII, No. 151, (1874), 8vo., London.
DITTO.

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DITTO.

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DITTO.

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THE SOCIETY.

MOSCOU.—Bulletin de la Société Impériale des Naturalistes de Moscou, Vol. XLVII, No. 3, (1874), 8vo., Moscou.
THE SOCIETY.

NEW HAVEN.—Transactions of the Connecticut Academy of Arts and Sciences, Vol. II, pt. 2, (1873), 8vo., New Haven.
THE ACADEMY.

PHILADELPHIA.—Journal of the Franklin Institute, 3rd Series, Vol. LXVII, Nos. 3 & 4, (1874), 8vo., Philadelphia.
THE INSTITUTE.

" Transactions of the American Philosophical Society, New Series, Vol. XV, pt. 1, (1873), 4to., Philadelphia.
THE SOCIETY.

" Proceedings of the American Philosophical Society, Vol. XIII, Nos. 90 & 91, (1873), 8vo., Philadelphia.
DITTO.

ROME.—Bollettino R. Comitato Geologico d' Italia, Nos. 5 & 6, (1874), 8vo., Rome.
GEOLOGICAL COMMISSION OF ITALY.

Titles of Books. *Donors.*

SALEM, MASS.—Fifth Annual Report of the Trustees of the Peabody Academy of Science for 1872, (1873), 8vo., Salem.

THE ACADEMY.

The American Naturalist, Vol. VI, No. 12, VII, Nos. 1—12, and VIII, No. 1, (1872-1874), 8vo., Salem.

DITTO.

TOKEI.—Lyman, Benjamin Smith. Preliminary Report on the first season's work of the Geological Survey of Yesso, (1874), 8vo., Tokei.

THE SURVEY.

TORONTO.—Canadian Journal, New Series, Vol. XIV, No. 2, (1873), 8vo., Toronto.

THE CANADIAN INSTITUTE.

VIENNA.—Jahrbuch der kais. könig. Geologischen Reichsanstalt, Band XXIV, No. 1, (1874), 8vo., Wien.

THE INSTITUTE.

„ Verhandlungen der kais. könig. Geologischen Reichsanstalt, Nos. 1-6, (1874), 8vo., Wien.

DITTO.

„ Sitzungsberichte der k. Akad. der Wissenschaften, Band XLVII, Abth. II, heft 4 & 5, Abth. III, heft 1-5, and Band LXVIII, Abth. I, heft 1 & 2, Abth. II, heft 1 & 2, (1873), 8vo., Wien.

THE VIENNA ACADEMY.

WASHINGTON.—Annual Report of the Board of Regents of the Smithsonian Institute for 1871, (1873), 8vo., Washington.

THE INSTITUTE.

„ HAYDEN, F. V.—Sixth Annual Report of the United States Geological Survey of the Territories for 1872, (1873), 8vo., Washington.

THE SURVEY.

„ United States Geological Survey of the Territories. Acrididæ of North America, by Cyrus Thomas, (1873), 4to., Washington.

DITTO.

„ First, Second, and Third Annual Reports of the United States Geological Survey of the Territories for 1867-69, (1873), 8vo., Washington.

F. V. HAYDEN.

„ LEIDY, JOSEPH.—United States Geological Survey contributions to the extinct Vertebrate Fauna of the Western Territories, (1873), 4to., Washington.

DITTO.

WELLINGTON.—Transactions and Proceedings of the New Zealand Institute, Vol. VI, (1874), 8vo., Wellington.

THE INSTITUTE.

YOKOHAMA.—Mittheilungen der Deutschen Gesellschaft für Natur und Völkerkunde Ostasiens, Jahrg. 1874, heft 4, (1874), fisc., Yokohama.

THE SOCIETY.

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OF

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THOMAS OLDHAM, LL.D., F.R.S.,

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RECORDS

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PRELIMINARY NOTES ON THE GEOLOGY OF KUTCH, WESTERN INDIA, resulting from the examination of that district, now in progress, by the Officers of the Geological Survey, by A. B. WYNNE, F. G. S., &c.

The detailed examination of this province has been long looked forward to with interest, as promising to cast light upon the geology of other parts of India where fossil land plants similar to some of those occurring in Kutch have been found to characterize an extensive group of rocks and are almost the only fossils which those rocks contain.

These plants were known to be associated in Kutch with a large number of marine fossils, the Jurassic age of which was determinable, but the relations between the beds containing forms so distinct had still to be ascertained.

With this view a hasty visit was made to the district of Kutch by Mr. W. T. Blanford of the Geological Survey, in 1863, and the conclusions to which his observations led appeared in a short paper among the publications of the Survey. (Vol. VI, pt. 1.)

Except this comparatively recent paper other sources of information regarding the geology of the country, prior to the present investigations, were almost limited to a paper by Captain, since Major, Grant, read before the Geological Society of London in February, 1837; some remarks upon it by Dr. Carter in "Geological Papers on Western India" published by the Bombay Government in 1857; a record of some fossils by Colonel Sykes (Geological Society, London), and an interesting notice in Sir Chas. Lyell's "Principles of Geology," describing the effects of the earthquake of 1819, the elevation of the "Allah Bund," and submergence of Sindree village on the Runn, north of Lukput.

Of these Captain Grant's paper is the most detailed, but while it contains many valuable facts, several of these seem to have been affected to distortion by geological theories, or views, which have vanished since he wrote, and also by a misappreciation of the stratigraphic arrangement of the rocks. The four or five-fold sub-division adopted by him, being natural, is correct, though the sequence was mistaken.

THE ROCKS CLASSIFIED.

The following may indicate the ultimate arrangement of the larger rock-groups, some of the newer ones being perhaps capable of further sub-division:

RECENT AND SUB-RECENT ...	Blown sand. Alluvium. Concrete.
TERTIARY	Tertiary beds and Nummulitic do. Sub-tertiary.
	Stratified traps and Intertrappean.
JURASSIC	Upper Jurassic (? Rajmahal.) Lower Jurassic ("Dogger," or Middle Jurassic.)
	Intrusive Traps.

[The syenite of Parkur-Nuggur, Kalinjur hill, &c., at the north-east corner of the Runn might be added to the above as the nearest base known for the Jurassic rocks.]

Of these the two Jurassic groups appear to have been transposed by Captain Grant under the names of "Older and Newer Secondary." The traps were looked upon as almost solely intrusive masses; their *interstratification* with aqueous beds being indicated at some places where association merely occurs, and at others where intrusion between stratified aqueous rocks takes place.

LOCALITY AND FEATURES.

The province of Kutch lies upon the west coast of Hindustan, about 400 miles north-west of Bombay, between the sea-ports of Kurrachee and Surat, or the provinces of Kattywar and Sind.

It is bordered on one side by the Arabian Sea and Gulf of Kutch, while upon all others it is isolated from the main land and the Thurr or little desert, by the grand and smaller Runns which are connected at the eastern side of the province. Its length from east to west is much greater than its breadth,* and, including the Runn, its area is estimated as being equal to about half that of Ireland.†

The whole province presents numerous alternations of hilly ground and open plains, sandy when covered by the detritus of the rapidly decomposing Jurassic rocks, and more earthy when underlaid by the Tertiary formation, both passing, towards the southern coast, into broad alluvial plains of ordinary Indian aspect.

The hills are perhaps as often clusters as extended in the form of ranges, though these latter do occur; and more or less continuous escarpments rising with the outcrop of some of the stronger beds are very frequent. A broken chain passes nearly east and west through the Runn islands of Putchum, Khurreer and Béla to Chorar, (in the former being flanked by a smaller range):—another borders the Runn on the north side of Kutch Proper:—one, called the Charwar range, runs east and west to the southward of Bhooj, the capital of the province: and there are lesser ranges in other parts of the district, with many clusters and isolated hills frequently conical in form.

The hills of the Wagur or eastern side of the district, take no definite direction. They are the denuded remnants of what would have been a somewhat flattened and rolling dome shaped mass if their strata were continuous instead of having been extensively operated upon by denudation.

There are no lofty elevations in Kutch; that which is reputed to be the highest, namely, Dhenodur hill, overlooking the Runn on the western side of the province giving a measurement (by Aneroid) of but 1,070 feet above the Runn; several others, however, have elevations not greatly less.‡

Nearly all the ranges and many of the hills are steeply scarped on the north, and pass by gentle slopes into the plains to the south as a consequence of their structure, the beds in general having long southerly inclinations at low angles from three parallel lines of disturbance or dislocation which extend, 1st, from Putchum Isle to Chorar; 2nd, from Lukput, along the south edge of the Runn, to Doodye towards Wagur; and 3rd, from near Roha to the neighbourhood of Butchao, passing at the northern foot of the Charwar hills. North of these lines, and just in their vicinity, the beds are much contorted, their highest inclinations being always in a northerly direction.

The trap hills, particularly those formed of intrusive traps, are frequently surrounded by precipices, or else sharply peaked; an irregular range, however, formed of, or capped by, the bedded traps, running north-west from their broadest development in the Dora hills near the centre of the province out through its western half, follows the usual rule presenting long slopes upon the dip and steep ones along the outcrop of the beds.

The northern side of the province, generally speaking, has much diversity of form, being often picturesque, while, owing to the absence of jungle and prevalence of sand, its aspect is nevertheless barren; particularly when the view lies across a parched and glaring plain edged

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* According to Captain Grant the extreme length is about 180 miles, and extreme width 50.

† 'Kutch Selections,' a collection of papers by various British Officials, published by the Bombay Government.

‡ Since writing the above, the height of a mountain in the Runn island of Putchum has been taken by Aneroid and found to exceed by some hundreds of feet any elevation measured in Kutch Proper. Dhenodur hill is not a volcano—see paper by Mr. Blanford, above mentioned.

by rugged hills, beyond a bright green patch with a few lonely palms, or other trees, near some village where wheat is laboriously cultivated with the aid of irrigation, and smoky clouds of sandy dust, raised by passing cattle, are driven before the northerly blast, from which those working at the wells shelter themselves by screens.

The peculiar bare, level and extensive plain called the Runn of Kutch is not a marsh, as represented upon some maps. It is periodically covered by water during the rains, and left dry, except a few patches, shortly after they have ceased; when those lower portions on which the water has lain the longest become strongly incrusted with salt,—this frequently extending as far as the eye can reach:—its dazzling surface flickering in the mirage, which magnifies or distorts any object that may happen to be upon the horizon. The source of the salt is probably from sea water, this being said to overflow the Runn, entering by the low ground at the mouth of the Koree river near Lukput, and also at the head of the Gulf of Kutch, when the sea on the coast is raised by the continued south-westerly monsoon winds.* However this may be, the waters from Kutch itself are strongly impregnated with salt derived from the rocks, great quantities of which in solution must be carried out to the Runn whenever there is sufficient rain to fill the rivers.

Although the incrustation is not very thick, being generally from one to two and a half inches, the quantity occurring on the Runn is enormous, and the way in which fish, insects and such organic remains brought in by the sea or down from the land by the Bunass and other rivers are preserved by the salt is evidence of the strength of the solution, if that were wanting.

Notwithstanding that traces of marine denudation are slight and scarce along the southern shore of the Runn,– having been probably removed by subsequent atmospheric action– its whole aspect strongly suggests its being a gradually raised sea-bottom; a broad and slightly elevated tract called the Bunnee, lying along its southern side between Putchum Isle and Kutch Proper, being very possibly a bank or bar formed by the rivers which flow from the higher land in that direction. Over this tract coarse grass, a heathery looking tufted plant and Bâbul trees are irregularly distributed.

Some of the results of the great earthquake by which this country was visited in 1819 are still to be seen in the fallen walls of several of the towns, in the "Allah Bund,"† a low elevation, thrown up by it, which is said to have permanently arrested the southward flow of the water of the Koree or eastern mouth of the Indus, and in the submerged village of Sindree on its left bank; part of the ruins of the fort only being visible above the mud, salt and water by which they are now surrounded, no other trace of the village remaining, and the basements of the building seen being buried in the silt.

Tradition has it that this was formerly the site of a large city surrounded by villages and fields, and to which the tidal ebb and flow reached: subsequently (from elevation of the land probably) the river became so shoal that boats could not reach the port; the city was in a great measure abandoned, and another Sindree built several miles further down the river at a place called Sindu on the map. Here the same thing recurred, and Sindu was deserted, a new city rising at Lukput, once an important place, but now consisting of a few houses in one end of the walled in enclosure. At present boats cannot come even so far as this, and Lukput Bunder is at a distance of three or four miles, while the sea trade is conducted at Kotaisir close to the old mouth of the Koree river. How far the first part of this statement may be true is involved in considerable uncertainty, but it is said there are records in the *Dufttcr* at Bhooj which would prove the accuracy of some portions of it at all events.

JURASSIC ROCKS.

The Jurassic rocks occupy a large portion of the northern half of the province extending through it almost from end to end, and also forming the hilly parts of the Runn islands before mentioned. The bold scarps and rugged hills exhibit numerous fine sections, showing plainly the structure of the country through which, notwithstanding repeated rolling undulations of the beds and some very marked anticlinal flexures, many recurring southerly and

* It does not appear to what extent this has been proved, though from the aspect of part of the coast it seems likely to be the case.

† Mound of God.

south-westerly dips place the lowest beds along the north side of the district, except where a great fault coinciding with the northern foot of the Charwar range causes them to re-appear in its centre.

These lower Jurassic beds consist mainly of gray, blue, red and black shales, thick and thin light-coloured sandstones and hard silicious flags, with some more calcareous varieties, and in some places quantities of dun-colored and gray compact earthy or sandy limestone. Pale-purple sandstones and some highly ferruginous bands also occur, the whole presenting so many varieties of color and kind that its general lithological aspect is seen to differ from that of the uppermost Jurassic rocks, sufficiently to warrant an attempt at sub-division, only by regarding the group as a mass and leaving details aside. The passage from the lower beds to the upper is so gradual that no very definite boundary can be assigned between them. Still there is a difference at the extreme ends of the series which would at once prevent their being mistaken for each other, and which, it is supposed, led to their separation into two groups by Captain Grant.

Owing to the numerous faults, undulations and the general lowness of their dip, the thickness of this great series of Jurassic rocks is difficult to determine with accuracy, but it has been assumed, from observations in the part of the district lying eastward of Bhooj, to reach from 4,000 to 5,000 feet, of which measured sections of over 2,000 feet have been made in the lower portion of the group; and there is no reason to suppose its aggregate thickness to be less in the western side of the province. Throughout this large accumulation of strata there is a marked absence of regular zones, indicating successive stages of deposition, and while in such an assemblage of coarse sandstones and muddy shales with frequent conglomeritic beds much constancy of lateral extension might not be looked for, and marks of succeeding zones be probably obscure or absent, no want of material seems to have existed to supply new or similar layers for those which may have died out. The whole formation, particularly in its upper beds, maintains the same characteristics of obliquely laminated strata alternating with finer and more parallel deposits, all of richly varying tints, from black to white, blue, red, orange, brown and gray, and sometimes green with a peculiar golden oolite among the lower rocks which glistens like avanturine.

The lower beds on weathering take frequently a rusty color, and dull olive tints are common, while, where the beds are highly calcareous, a whole mountain formed of them with rounded outlines and a whitish hue in sunshine looks cool, and in cloudy weather as gray as any granite hill. Thick bands of a warm orange sandy limestone with some red beds occur also in the lower rocks, and many of their shales are gypseous.

The upper beds are marked by a predominance of clean white gravelly sandstone with some blackish ferruginous bands and white or lavender-gray, sometimes highly carbonaceous, shale. Between these and the lower beds alternations of almost every variety of rock in the formation occur, ranging through a vertical space equalling a third of the total thickness if not more. Many of the beds in both groups are strongly saline.

The lowest beds are much the most fossiliferous, and the remains are chiefly marine, including *Ammonites*, *Pleurotomaria*, *Ostrea*, *Trigonia*, *Cucullæa*, *Corbula*, *Gryphæa*, *Modiola*, *Terebratula*, and numbers of other bivalves, *Echinida*, *Crinoids*, *Corals*, *Belemnites*, fish teeth, reptilian bones, and fossil wood.

In one certain and one or two doubtful instances some of the upper beds of this lower and marine series were found to contain impressions of (terrestrial) *Zamiæ* in shaly bands interposed between the marine shell-bearing beds. During the examination of Eastern Kutch, the most exhaustive search that could be made failed to find any thing among the upper rocks except these *Zamiæ* and a few other terrestrial plants, but in the west, in a few cases, some marine fossils have been obtained from single beds occurring amongst unfossiliferous strata of the upper portion of the rocks, but still below the uppermost (white) beds seen.

This alternation or intercalation of the marine and freshwater beds (presuming those containing *Zamiæ* to be of purely freshwater deposition) being one of the points to which attention was specially directed, it is satisfactory to have so far ascertained the fact after many months of close search, even though such alternation appears to be much more limited than was supposed, unless it is taken for granted that the numerous fragmentary grass-like plant remains so common in the shales and flaggy sandstones throughout the formation are of freshwater deposition also. Many of these have been searched over and over again without a trace of a *Zamia* leaf being found, and there seems to be no more reason for supposing them freshwater than some other beds in which ammonites occur lying among a mass of vegetable remains, the woody fibre of which is generally distinguishable, though often obliterated by carbonisation.

Such intimate association of the *Zamiæ* with marine forms has not, it is true, been discovered, but nevertheless it may not be unreasonable to suppose that these plants were floated out from land, and deposited by the sea at depths unsuited to the marine life of the period or at localities where this was from other causes absent. As Mr. Blanford has observed in the paper above mentioned, 'no sudden change in the rocks nor any unconformity has been found to mark the transition from a salt to a freshwater period;' and while it is evident that land plants may be carried out to sea, though marine organisms cannot so readily find their way into freshwater deposits, it is easier to believe that the whole of these salt Jurassic rocks are of marine origin than that repeated alternation of fresh and salt water beds takes place without any marked difference of character or aspect occurring in the rocks.

It may also be observed that though there are but few evidently marine beds, and these not immediately associated with Zamia-bearing rocks in the *upper* part of the Jurassics seen, still these *Zamia* beds contain plants only, no freshwater shells, fish, nor animal remains occurring to contest the possibility of the containing rocks being of marine or perhaps estuarine formation.

Great as is the thickness of the Jurassic beds, it is that only of a portion of the group the base of which is not visible, and the upper beds being unconformably overlapped by the Bedded Trap, they may continue to increase in quantity beneath the latter much further than they can be observed. There are, however, some appearances, along their uppermost boundary, which may be slight indications that the Jurassic period was drawing to a close, and that the deposition of rocks much resembling some of their upper beds ushered in the commencement of the succeeding unconformable tertiary group in those places at least where this succession was not interrupted by the accumulation of the intervening Bedded Trap.

TRAPS.

By far the largest part of the trap rocks is referrible beyond a doubt to the same period as the vast stratified accumulation known as the Deccan Traps. Some of the lowest flows are very thick, presenting few or no traces of bedding for more than 100 feet, but further up this is as plain as all the other appearances, such as beds of red bole, alternations of amygdaloidal and columnar basaltic flows, presence of zeolites, and so forth, which characterise the formation elsewhere. The trap is sometimes magnetic, and among its lower beds ashy sandstone or calcareous bands occasionally exist. In one place near its local base an interstratified bed of friable red sandstone 30 feet in thickness was observed, and in another a small lenticular deposit of intertrappean calcareous rock containing small fish scales.*

The flows or beds have a low steady southerly or south-westerly inclination, forming a wide hilly belt through the centre of more than the western half of the province, but their deposition does not seem to have extended to the place occupied by the eastern extremity of the district. The thickness of this formation is much less than usual, being estimated at about 2,500 feet.

An obscure group of earthy sandstones formed largely of trappean materials, often indistinctly bedded and containing woody plant impressions, occurs in several places, having but indefinite relations to the lower part of the Bedded Traps, but resting quite unconformably on the Jurassic rocks and often closely associated with masses of intrusive trap near which also white sandstone is often strongly columnar.

The intrusive traps—occur chiefly in the Jurassic area, and probably mark some of the places from which those just mentioned issued.

They consist generally of augitic or basaltic traps varying in color (different black and grayish hues), and in texture from a close compact rock to one coarsely crystalline, the crystals of glassy felspar being interlaced, and the deeply weathered soft light-colored surface taking

* Within the last few days information has been obtained of the discovery by Mr. Fedden of intertrappean beds, containing *Physa Prinsepii*, in the western extension of the trappean formation, furnishing still further proof of the identity of these with the Deccan Traps.

much the appearance of a syenite in similar condition. Fine muddy-looking or ashy trap, weathering to an olive-green minutely divided detritus, is another variety. Some of the dykes, &c., are of fine-grained purple colored trap, with white steatitic specks, a soft earthy or lava-like texture, are much less dense than the varieties abovementioned, and are sometimes salt to the taste.

With regard to the manner in which all these intrusive traps occur, nothing could well be more varied: dykes are particularly numerous in some localities; they also occur in faults, while local intrusions form hills projecting from the plains and Jurassic broken ground, like knots in decaying wood. In such cases, their outlines are either conical or combinations of this with steeply scarped forms. Some intrusions range through the country for many miles, presenting the most irregular lines both in plan and elevation, cutting across the aqueous strata, including large masses, intruded between them or forming hills either capped or underlaid by the Jurassic beds, or both one and the other, these being altered by the contact into various kinds of porcelainous or quartzitic rock, while one case occurs where a whole stream section of the aqueous rocks seems to pass by gradual intensity of alteration into solid trap in which planes resembling the original bedding can be traced for some distance as if the strata had been melted *in situ*, no marked difference of texture however existing in the trap, although the stratified rocks consist of alternations of calcareous sandy and thin shaly bands.*

Other instances occur in which sandstone seems to have been completely melted and taken up by these traps; the matrix having yielded first and the quartz fragments and grains gradually becoming more separated and disappearing until they are quite lost at a very short distance in the dark trap. This can be seen in hand specimens.

Generally speaking, these large intrusions have an intricacy of arrangement forming a tangle which defies all effort at accurate representation upon a map of small scale, and sometimes their basaltic trap is so magnetic as to deprive compass bearings taken from these points of any value, the variation being of inconstant amount.

SUB-TERTIARY GROUP.†

As already stated, the Jurassics or Dogger beds of Kutch, consisting of a calcareous or sandy and shaly marine series below, passes upwards into alternations of more ferruginous and more purely argillaceous and arenaceous beds,—in which land fossils (Zamiæ, Ferns, &c.) are either rare or locally numerous,—these forming what are at present considered an upper member of the same group. At some period subsequent to the Jurassic, not clearly marked, but arguing from local as well as distant sources of information (in the Deccan and at Bombay), probably an early Tertiary one, the volcanic activity which produced the Bedded Traps came into operation. Observations here only show that traps were extensively intruded through the Jurassic rocks, and that other traps, very probably connected with these as centres of eruption, constitute a thick series resting with marked unconformity upon these Jurassic strata.

But overlying the Bedded Traps and, where these are absent, the rocks upon which they rest, is a marked band of most peculiar aspect, having, in contact with these traps, a very volcanic appearance, but one entirely different from theirs. Its predominant colors are deep red and pure white, but it is finely varied with purple, orange, greenish, brown and black or blue tints, even brighter and more strongly contrasted than those of the Jurassic beds. Its lowest stratum in junction with the uppermost of the trappean flows is a curiously mixed and mottled one, brecciated, concretionary on a large scale, in places containing small white quartz grains, but generally consisting of a pure chalk-white or variegated purple and lavender, unctuous, argillaceous, rock occasionally saline and speckled with white kaolin patches, giving it the appearance of an amygdaloid, sometimes to such a degree that it becomes undistinguishable from the purple trap found in several dykes among the Jurassic rocks.

* This passage as it were of stratified into intrusive amorphous rock is so very peculiar that it may perhaps be deceptive. A place where the alteration of the beds ceased laterally and the trap might be said to commence was sought for in vain, and the lines which may be, or at least simulate, original stratification apparently continuous with those of the unaltered bedded rock cease to be traceable beyond a few yards into the trap.

† The name Sub-Tertiary used here is only provisional. An examination of the fossils will probably cause it to be altered for another. It merely means that the beds are below the highly fossiliferous Nummulitic and other Tertiary beds though above the Bedded Traps the Intertrappean beds of which are believed to be of Lower Tertiary Age.

Along the line of junction with the underlying Bedded Traps their uppermost layer is very commonly a greenish amygdaloid, also more or less generally concretionary, rusty or decomposed looking; instances occurring in which the concretions of the mottled rock have been found to exhibit an apparent passage towards their centres from one variety to the other, the cores being formed of rusty amygdaloid quite similar to that beneath. In other cases the lowest stratum of the mottled series or uppermost one of the trap is a pale greenish earthy trappean looking rock, not quite so concretionary as usual, with much of the external character of the mottled breccia, but containing yellowish green steatitic amygdala. Where these sub-tertiary beds rest on the Jurassic rocks the peculiar brecciated white bed is seldom strongly developed, but still is frequently present.

This breccia passes upwards within greater or less distance, as the bed is thick or thin, into gnarled and ponderous laterite of various red, black, brown and purple tints, either brecciated or of the brick-like character so well known elsewhere.* Its junction with the white rock below often shows rough stalactitic looking masses of the laterite vertically penetrating the lower bed all along the line of contact as if infiltrated from above. In the same group are other bands of laterite and some very coarse obliquely laminated white quartzose and ferruginous sandstone containing much of the white earth distinguishing the lower layer. Associated with these, but not always upon the same horizon exactly, are dull purple, brown and black, in some places highly carbonaceous, gypseous or pyritous shales containing numerous impressions of large and small *exogenous* and *endogenous* leaves. These occur also in fine flaggy pale lavender or white beds of the same group, but of uncertain place.

Apparently among gypseous reddish shales of this group a thin band was found to contain *Fasciolaria, Arca, Nucula, Cyprina* and *Venus*, which are not, however, in such a state of preservation as to warrant more than an opinion at present that they may be of either cretaceous or eocene age, while some bones of large reptiles, including part of a skull, have been found in very similar shales and on what seems to be very nearly the same horizon.

Close above these some brown flaggy sandstones containing a few shark's teeth and shells and occasional beds of earthy orange mudstone begin to appear, and indicate the approach to others abounding in tertiary fossils.

The thickness of this group (the 'Red—? New Red-sandstone' of Grant) varies much, from a mere band consisting of a few beds or only one, to a maximum, in some places, of between two and three hundred feet. Until the fossils have been examined, it is obviously difficult to say how much of this group may be of Tertiary age, if indeed it be not entirely so. It forms a marked basement to that series however, and where it rests upon the Jurassics without the intervening trap, its junction very commonly appears quite conformable, the line, however, being almost impossible to see when the gypseous shales of the one group overlie those of the other.

TERTIARY FORMATION.

As the Tertiary rocks are still undergoing examination, they can be but slightly noticed here, although they form a large and important feature in the geology of Kutch.

Their principal development takes place in the southern half of the western side of the district, where they form wide rolling plains under which the beds undulate, wrapping round the western termination of the Jurassic and Trap formations, and appearing at intervals along the southern shore of the Runn, on the margin of at least one of its islands, and at a few spots in the eastern portion of the province.

They consist, as a mass, of rubbly shales interstratified with yellow mudstone bands, and thick beds of sand or sandstone. Occasionally the rocks become sufficiently calcareous to be called limestone, and most of those containing fossils are highly so—an agglomeration of shell-casts in an earthy or sandy calcareous matrix.

Among the lower beds *oysters* and *turritella* are particularly numerous, whole beds being formed of the latter, and a flat echinus (*clypeaster*), being very common.

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* At some localities in Eastern Kutch the laterite is associated with quantities of Agates both *in situ* and left in a thick layer by its weathering down, strongly recalling the appearance of some very similar ground similarly situated near the base of the tertiary rocks in Guzerat.

At a short distance above the base of the formation, on an average not more and often greatly less than 200 feet vertically, are soft and harder white calcareous beds crowded with *nummulites* and *fasciolites*, the former of several kinds, and associated with them are numerous *echini*, bivalves, &c.

The Nummulitic beds are generally nearly horizontal; they produce ground of singularly barren aspect, reminding one of the Egyptian desert, the white nummulites weathered out lying thickly upon the surface in place of soil, and from their abounding in that neighbourhood being called by the native Lukput paisa.

For several miles eastward of Lukput, along the edge of the Runn, these rocks are brought against the Jurassics by a fault, and having followed the low ground round the western limits of Kutch they disappear for a considerable space in the country north and north by east of Jackow, but set in again in the low lands further east.

In other parts of the low country, unoccupied by the Nummulitic group, highly fossiliferous tertiary rocks abound, containing a large number and great variety of genera, including *turritella, ostrea, conus, fusus, voluta, strombus, natica, trochus, oliva, cassis, cerithium, scalarium, cypræa, balanus, pecten; clypeaster, cidaris,* &c.:—of crustacea, some well preserved crabs, besides large bones and great molar teeth, and very many other interesting fossils, complete lists of which it is hoped will hereafter appear.

The thickness of these rocks is not yet sufficiently clear to be stated, but is considerable, probably exceeding 500 or from that to 800 feet.

It seems most likely that these Tertiary beds have been deposited in shallow water under shore conditions and subject to causes producing great irregularity of deposition. The occurrence of leaf beds in the group repeats the case of the Jurassic beds with regard to the alternation of fresh and salt water periods, and among the upper beds the predominance of sands almost devoid of organic remains indicates a different state of things from that under which the highly fossiliferous strata accumulated.

POST-TERTIARY.

In several places a coarse concrete is found containing numerous fossil oysters, generally of large size. It appears to rest unconformably upon the Tertiary rocks, and may be an old member of the coast series or "littoral concrete" of Western India.

Other post-tertiary and superficial deposits, such as alluvium, blown sand, river concrete, and a rock much resembling the latter, found high upon the uanks of many of the hills, have merely to be mentioned, their occurrence here being in all respects similar to that in other localities.

Coal is often mentioned as occurring in Kutch. Carbonaceous shales have been met with in several places both in the Jurassic and Tertiary rocks, but chiefly in the former, and these sometimes contain layers of bright coal. This is usually very thin, forming but small parts of the bands quite too limited in thickness and extent (so far as known) to repay the cost of working.

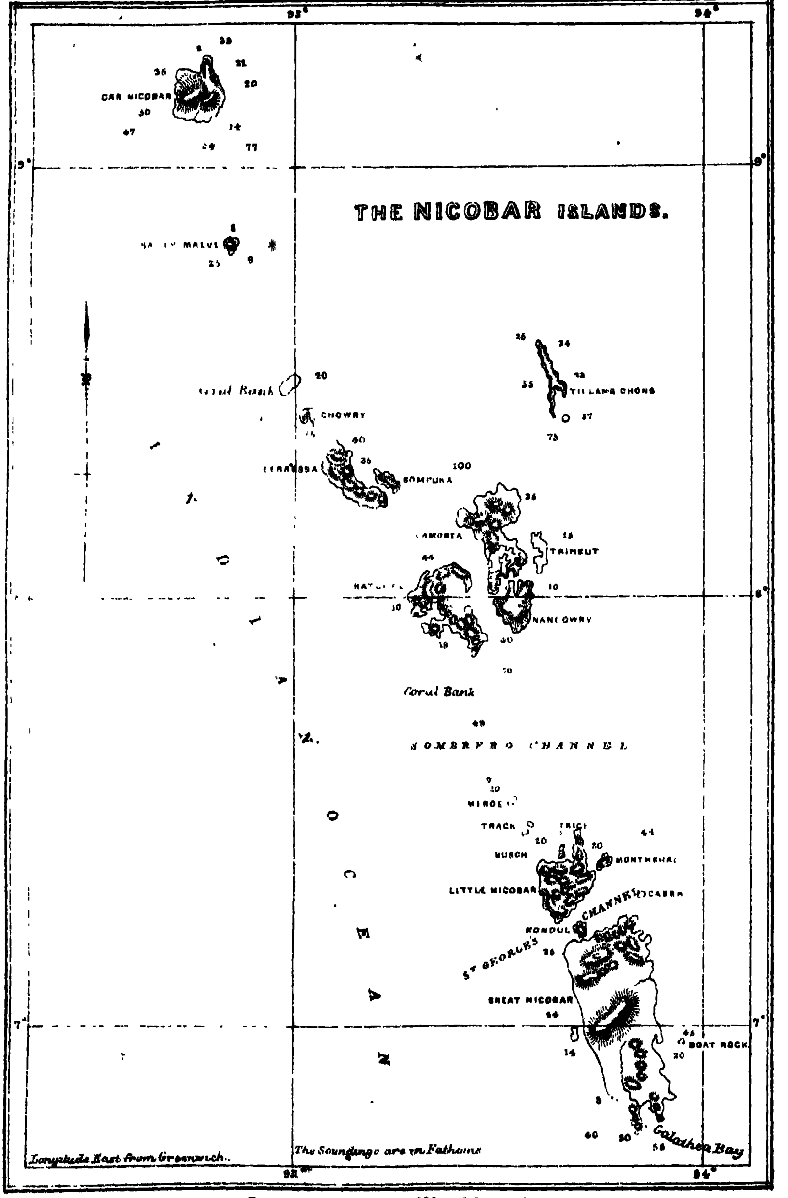
The largest layer, opened upon formerly at the village of Trombow, north-north-east of Bhooj, is now concealed by the workings having fallen in.

Alum is extracted in considerable quantities from the sub-tertiary shales of Western Kutch.

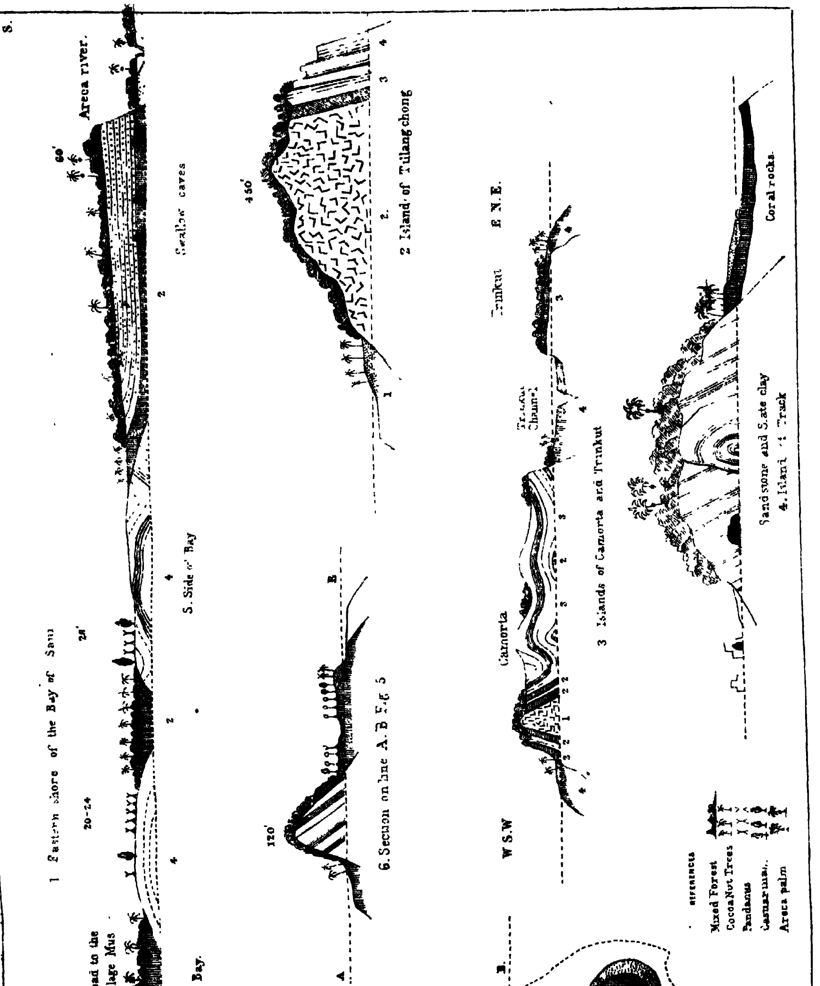
Iron used to be made in various parts of the province, but the manufacture has ceased in consequence of the facility with which Foreign iron can be obtained.

In conclusion, it remains only to be stated that several points of interest necessarily passed over in this hasty sketch have been reserved for subsequent consideration in the report to accompany the map, data for which are still being collected.

Amongst these are some facts tending to afford further proof of the association of aqueous deposits with the earliest beds of the Stratified Trap, and also indications that their highest flows or beds were not much older than the lowest Tertiary rocks, if indeed some of them were not contemporaneous.



Printed at the Geol. Surv: Office, Calcutta, 1869


N.
S.
1 Eastern Shore of the Bay of Sau
Areca river.
60'
Swallow caves
Road to the village Mus
N. Side of Bay.
20-24
28'
S. Side of Bay
450'
2 Island of Tillangchong
120'
6. Section on line A. B Fig 5
W.S.W
E.N.E.
Trinkut
Trinkut Channel
Camorta
3 Islands of Camorta and Trinkut
Coral rocks.
Sandstone and Slate clay
4. Island of Track
5. Island Pulo Milu
References
Mixed Forest
Cocoa Nut Trees
Pandanus
Casuarinas
Areca palm

The occurrence here of the persistent and well-marked band of laterite and its associated white clay or steatitic breccia, passing conformably upwards into the Tertiary beds, and less regularly, but still with an appearance of transition, into some of the bedded traps below, though differing from certain of the facts observed in the country north-east of Surat, may possibly modify some of the conclusions with regard to the more obscure occurrence of the same three groups, *i. e.*, the bedded traps, lateritic beds, and Tertiary rocks of Guzerat, or may, at least, confirm the impression of the volcanic activity which produced the bedded traps dating from early Tertiary times.

If, in the absence of fossils, lithological similarity be admitted as evidence, it may be possible that some of the white felspathic sandstones, considered as Upper Jurassic, overlying the Zamia-beds of Kutch, may represent some of the frequently similar looking Mahadeva or Bâgh beds of Central India and the Nerbudda Valley.

The evidence for a Jurassic age comes chiefly from the lower part of the series, which is certainly marine so far, and the occurrence therein of a band of shale containing *Zamiæ* may bear the explanation before suggested, but at present the discussion of these points is almost premature.

April, 1869.

Much interest having been excited in the history of the Nicobar Islands, which have recently been taken possession of in the name of Her Majesty the Queen of England, I have thought it desirable to print here a brief summary of all that is known regarding their geological structure. This could most effectively be done, by giving a translation of the reports of Dr. F. v. Hochstetter, who accompanied the Austrian '*Novara*' expedition as geologist. Dr. Stoliczka, long a colleague and friend of Hochstetter's, has translated this report. The geological portion is given nearly at full. The part relating to the vegetation and its connection with the soils, however interesting to those who have never seen a tropical vegetation, contains little that would be new to residents in this country; and only a few extracts are given. A few remarks on springs and temperature conclude the paper.

The geology of the Nicobars has many points of the highest interest to the Indian geologist, as bearing on the structure of the adjoining Andamans, and the continuation of the same features into Burmah and northwards, on which connection some information will be given in future numbers. T. O.

CONTRIBUTIONS *to the* GEOLOGY AND PHYSICAL GEOGRAPHY OF THE NICOBAR ISLANDS, *by* DR. F. VON HOCHSTETTER, *(translated by* DR. F. STOLICZKA, *from the "Voyage of the Austrian Frigate* NOVARA *round the world in* 1857-1859." *Geological part, 2nd vol., pp.* 83-112. *Vienna,* 1866).

The Nicobar islands (Pl. 3.) belong to an area of elevation which can be traced from the Bay of Bengal far into the southern seas. Beginning under the 18th degree north latitude in the group of the Cheduba and Reguain islands on the coast of Arracan, passing through the Andamans and Nicobars, then continuing through Java, Sumatra, and the south-western group of the Sunda islands, this line of elevation bends in an oblique S-form through New Guinea, to the north of the Australian continent, and forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie islands being possibly considered as the extreme southern end of this curve. Winding from the northern into the southern hemisphere through 70 degrees of latitude, this line, or area, is characterized as one of elevation by two phenomena, totally different in their nature, but nevertheless equally grand, and in certain respects related to each other. These phenomena are, first, the activity of the interior of the earth, showing itself in the volcanic action; and secondly, the activity of the coralline animals, disclosing itself in the formation of that kind of coral reefs which Darwin has distinguished from the barrier or lagoon reefs under the name of fringing or coast reefs.

Both phenomena, the volcanic action with its elevatory power, and the formation of coast reefs, are, in certain respects, related to each other, as has been placed beyond a doubt by Darwin's observations, although both do not appear together along all parts of this area.

In the southern extra-tropical latitudes, where coralline life does not exist on that large scale, the volcanic action is the only marked one, and equally so in tropical latitudes to the north of the equator,—where that action is locally wanting,—the peculiar formation of coral reefs must be considered as the principal argument for the continuation of this line of elevation. This is the case at the Nicobar islands.

These islands occupy a gap without volcanoes, between the volcanic range of Sumatra, and the Barren and Narcondam islands, which lie to the east of the Andamans.

Whatever may be hidden in the interior of the Nicobar islands, covered with perfectly impenetrable primeval forests and grassy plains, the occurrence of younger volcanic rocks is the least probable. Although I have found on the north side of Car-Nicobar, the northernmost of the islands, two pieces of a porous basaltic rock, the size of a man's hand, in a coarse gravel in the forest near the village Mus, and a larger angular fragment in the coral sand on the strand near the village Saui, still there is more reason to believe that these fragments were transported to the coast of Car-Nicobar in the roots of stranded trees,* or even that they were remains from the travelling bags of the Danish naturalists of the Corvette *Galathea*,—who in 1846, shortly before they landed on Car-Nicobar, visited the volcanic Barren island,—than that they came from the interior of the island. I have in vain searched for similar pieces in the stream- and river-gravels of Car-Nicobar, and I have not met with them on any of the other islands on which we landed.

On the other hand, the Nicobar islands are distinctly characterized as a portion of the chain of oceanic elevations, which began in former geological periods and still continues, by the upheaved coral banks and by the continuous formation of coral reefs, which slowly, but in the course of hundreds and thousands of years perceptibly, enlarge the territory of the islands.

The Austral-Asiatic area of elevation, above indicated in its entire extent, has in the Nicobars a mean direction to north-20°-west or from south-south-east to north-north-west, possessing a length of 148 Engl. (=37 Ger. geogr.) miles, and a width of 16 Engl. (=4 geogr.) miles. This direction indicates at the same time the strike of the strata on all the islands, while the dip is either towards east or west. The synclinals and anticlinals in the geological structure of the islands are thus coincident with the direction of the great geological line of elevation which connects the northern point of Sumatra with the group of the Andaman islands.

The total area of all the islands is calculated to be 33 to 34 German (geogr.) square miles (equal to about 528—544 Engl.).

1.—*Geological Formations.*

To render properly intelligible the results which will be given in the following pages, I may be permitted to make a few preliminary remarks.

It is at present extremely difficult to make any detailed geological observations on the Nicobar islands. One is limited to the sea coast, as impenetrable forests and grassy plains make the interior of the islands perfectly inaccessible and hide the rocks. On the northern smaller island, this circumstance is of less importance, because the extent of the rocks through the whole island can easily be ascertained, as soon as it is possible to observe them on two opposite sides of the coast in the same stratigraphical relation. The case is different with the southern larger islands. Sambelong or Great Nicobar has an area of 17½ geographical square miles, and is larger than all the other islands put together; it offers in the mountain ranges (rising up to 2,000 feet), and deep valleys, such a variety in the configuration of the ground, that it is impossible to suppose that what is to be seen on one or the other point at the coast should be characteristic for the whole island. The mouths of rivers being generally occupied by mangrove swamps, it is even impossible to come to any conclusions from gravels as to the rock which is to be found in the interior. But even on the coast there are great obstacles to geological investigation. Wherever the inquiring eye of the geologist observes promising cliffs, there breakers make it generally impossible to land, and where landing can be effected, we usually meet only a flat coast.

* Chamisso mentions the transport of stones in the roots of stranded trees on the Radek group, and Darwin gives a similar example from the Kieling islands. (Darwin's natural history travels, part II, p. 242).

Thus one is limited in his observations to the few points, where during low water it becomes practicable to reach from the sandy shore some rocky promontory; and even under the best circumstances I was always restricted to that part of the coast on which the frigate anchored, for no amount of promises and offers could induce the natives to undertake longer trips with their canoes, neither was it possible to obtain a boat from the frigate at my disposal. I hope that other geologists, who may in future visit these islands, will be more successful in this respect.

My observations were therefore confined to the following places:—

1. *North-western coast of Car-Nicobar.*—A low precipitous coast accessible along its entire extent. Thick clay beds, with some more solid strata of sandstone, containing *Fucoids*, are on this coast overlaid by upheaved coral banks (coral conglomerate and coral sandstone); these are in some places still in direct communication with living coast reefs.

2. *Southern Bay of Car-Nicobar.*—Flat coral ground with fringing reefs, and at the breakers banks of a recent sandstone.

3. *Novara Bay on the west coast of Tillangchong.*—Precipitously rising cliffs of serpentine and gabbro conglomerate; at the breakers' coast reefs.

4. *Channel between Camorta and Nancowry, or the Nancowry Haven.*—A deep transverse cleft through yellow clay-marls containing magnesia, alternating with beds of serpentine and gabbro traps, and pierced through by serpentine and gabbro. A long stretching coral reef formation exists in the channel, but coral ground is very limited.

5. The small islands *Trice* and *Track*, north of *Little Nicobar*; precipitously upheaved; clayey sandstone beds with imbedded pieces of bituminous brown coal; coral and conglomerate banks and fringing reefs.

6. *Pulo Milu.*—A small island on the north side of Little Nicobar, consisting of strongly raised sandstone beds, with flat coral ground, fresh water alluvium, and fringing reefs round the whole island.

7. Island *Kondul* on the north side of *Great Nicobar.*—Sandstone, sandy slates, and beds of clay-marl alternating with each other, flat coral ground of very limited extent, fresh water alluvium, and fringing reefs.

8. *A small bay on the northern coast of Great Nicobar.*—Sandstone hills, salt-and brackish-water swamps.

9. *East side of the southern bay* (Galathea Bay) *of Great Nicobar*, in which flows the Galathea river; sandstone mountains; flat coral ground, coral and conglomerate formation at the level of the breakers, fringing reefs; pebbles of bituminous coal on the strand.

These places are, with the exception of Car-Nicobar, the same as were seen by the Danish geologist Dr. Rink, accompanying the expedition of the Danish Corvette *Galathea* in 1846, and were, beside many others in the Archipelago, visited by him during a stay of four months, described in a special work.*

As to scientific inquiry, I left the Nicobars quite unsatisfied in spite of the comparatively long time of one month which we spent in their waters; I know well how little my own observations increase the geological knowledge of the islands, for which we are indebted to Dr. Rink; for just the grandest objects, the islands *Terressa*, *Little* and *Great Nicobar* remained for me totally a *terra incognita*. But I am conscious to have done every thing that it was possible to do under the circumstances, and in this point of view the few observations I can offer must be criticised.

Car-Nicobar is a low island, the average height of which above the level of the sea amounts to about 45 feet; only two ridges, which may be from 180 to 200 feet high, rise in the interior above the forest covering nearly the whole island. The west, south, and east, coasts are flat and sandy, and the north-west and south-east monsoons accumulate upon them gradually higher and higher fragments of corals and shells, which pass over the fringing reefs surrounding the whole island. The south coast is in part swampy, only the northern or rather the north-western coast, forming the shore of the bay of Saui, is precipitous, allowing a view of the geological structure of the island; the section of this coast is given

* Die Nikobarischen Inseln, eine geographische Skizze, mit specieller Berüchsichtigung der Geognosie, Kopenhagen, 1847. (The Nicobar islands, a geographical sketch with special reference to geology).

in the sketch Pl. 4. Fig. 1.—*Eastern shore of the Bay of Saui.* 1, Loose coral and shell-sand: 2, Dead coral-banks: 3, Indurated rock-beds of dead corals and shell-sand: 4, Plastic-clay with bands of sandstone.—

The eastern shore of the bay gradually rises from north towards south up to a height of about 60 feet, and includes two small lateral bays in which massive banks of a gray clay crop out below upheaved coral banks which form the projecting corners of the cliff. It is very characteristic that the boundary of the calcareous and clay strata on the surface of the coast terrace is at the same time a sharp limit of vegetation, inasmuch as on the clayey ground the *cocoa-palm* is replaced by *Pandanus, Casuarina* and grass, forming locally quite extensive grassy plains. The clay deposits, without any distinct stratification, show a cubical cleavage. The prevailing color is light-gray, only single bands are darker colored, others are ferruginous, containing numerous clay-ironstone nodules. The clay is a little calcareous, effervescing with acids. In the southern lateral bay also appears between the clay beds a more solid stratum from two to three feet thick, and from its projecting part larger and smaller plates are broken off. On one of these plates I observed the impression of a large species of *Fucus (Chondrites Nikobarensis,* Hochst.) The strike of the strata is from south-south-east to north-north-west in both bays, the greatest thickness observable in the strata amounts to 20 or 30 feet. This clay deposit on the northern coast of Car-Nicobar is characterised as a marine formation by the numerous *Foraminifera* which it contains, but I did not succeed in finding any recognizable remains of *Mollusca,* except indistinct and badly preserved bivalves *(Pelecypoda).**

Farther towards the south, the clay beds again sink under the level of the sea, and in their place again appear coral banks, the precipitous coast becoming constantly higher, but at the same time gradually more inaccessible. On this coast the sea has washed out deep hollows, and the coral-banks are overlaid by massive banks of a white rock consisting of shell and coral sand, and being rather soft on the weathered surface. On the Areca river, in the innermost corner of the bay of Saui, the plateau of about 60 feet rapidly terminates with a fault, and the southern shore of the bay only exhibits a flat sandy strand richly overgrown with cocoa trees, being at the same time thickly populated. Judging from a few lumps in the gravel which I found on the northern as well as on the southern side, I conclude that there is somewhere in the interior of the island a gray fine-grained sandstone with little flakes of white mica and also a compact limestone *in situ.* The natives use the sandstone from the gravels as grinding stones.

Batty Malve is a small rocky island with precipitous shores all round. It rises on the south-eastern and eastern side in two terraces to about 150 feet. On the western and north-western side, it runs into a low flat cliff; judging from a distance of two or three nautical miles—we did not come nearer—the island is inaccessible. The extreme shore seemed to be covered with grass only, the interior was a low jungle, the crown of cocoa-palm being here and there visible at its margin. Only opposite Car-Nicobar can the island give an impression of a "relatively bare rock," as Steen Bille† says.—The rocks to be found on the island are most probably the same as those of Car-Nicobar.

Tillangchong, situated opposite Car-Nicobar, is a narrow mountainous island with precipitous cliffs, stretching from north-west towards south-east; it consists of two ragged mountain ranges separated by a depression of only 30 feet in depth. Where, on the south-east side, both ranges meet, a deep bay is formed, which during the north-west monsoon offers an excellent place for anchorage. The less precipitous south-western coast is accompanied by a few rocky cliffs, while the north-eastern coast is highly precipitous all along the shore. The highest hills are situated in the northern part of the island, apparently rising to an elevation of about 500 feet. Serpentine and gabbro form no doubt the great mass of the island.—Pl. 4. Fig. 2.—*South-east coast of Tillanchong.* 1, Coral-rocks; 2, Serpentine and Gabbro; 3, Breccia; 4, Sharply elevated rock-beds.—

In the small bay on the south-western coast, the Novara bay, in which the frigate was lying at anchor for a few hours, the irregular and cliffed-like shores are composed of common

* The description of the very well preserved *Foraminifera* from the above described clayey beds was undertaken by Dr. K. Schwager. His very valuable paper will be appended to this chapter of the Nicobar Islands, and for farther results I here refer to this paper.

† Captain Steen Bille was Commander of the Danish ship *Galathea.*—T. O.

serpentine, often traversed with veins of hornstone, and the same is the case with the thickly wooded mountain slopes, as far as could be observed in the small rocky beds of streams. The shore exhibited a very great variety in the color of the serpentine, jasper and hornstone pebbles: besides these, however, there were noticed also numerous pebbles of a dark green diallage rock, which must no doubt be *in situ* somewhere on the same coast at no great distance.

From the angular fragments of serpentine and other masses in the course of decomposition, a ferruginous breccia is formed at the foot of the hills, while in the breakers the serpentine gravels are being cemented by coral and shelly sand forming solid sandstone and conglomerate banks which recall the Verde-antique, (Ophicalcite). The plateau of the coast-reefs extends 2 to 300 feet from the precipitous shore into the sea. The whole of the island was covered with thick primeval forest which thrives well, even on the serpentine ground.

In passing along there were observed on the southern part of the island and on the eastern coast thin-bedded rocks with a high dip; these were in massive cliffs almost perpendicular in the south-eastern bay with a columnar structure; their true nature remained, however, unknown to me, for I was unfortunately obliged to use the telescope in place of the geological hammer.

Camorta, Trinkut, Nancowry with *Katchall* form the middle group of the Nicobar islands. Trinkut is situated in front of the eastern entrance of a channel between Camorta and Nancowry; it is a low island surrounded by coral reefs, and on its southern coast whitish-yellow argillaceous marls crop out. *Camorta* and *Nancowry* exhibit a greater variety of formation.—Pl. 4, Fig. 3.—*Sections of Camorta and Trinkut.* 1, Gabbro and Serpentine; 2, Breccia and tufa; 3, Clay marl with sandy beds; 4, Coral-rocks.—The channel between the two islands, the Nancowry haven, has numerous small bays and corresponds with a transverse cleft, while the Trinkut channel is a longitudinal cleft. The precipitous shores of the former offer, therefore, the most instructive geological section.

The narrow western entrance to the Nancowry channel is marked by two projecting rocks, which have been washed out by the force of the waves, making thus a natural gateway of rocks. Both cliffs rising almost perpendicularly to about 80 feet, are formed of a coarse breccia, composed of angular fragments of serpentine and gabbro* firmly cemented. I could not observe any stratification in this rock on the Camorta side; it is here in cliffs with large quadrangular blocks. On the Nancowry side, however, coarser bands alternate with finer tufa-like ones, with a strike from south-south-east to north-north-west and dipping about 85 degrees towards west. On the Camorta side, there crop out at two places below heaps of masses of rocks, which Rink very properly regarded as friction-breccias, cliffs of a more or less serpentine or gabbro-like massive rock.

Among the pebbles on the strand, I also met with numerous fragments of a reddish-brown rock traversed by white calcite veins, the rock which Rink called Eurite.

These phenomena at the western entrance to the Nancowry-haven are thus perfectly identical with those which Rink has observed at the entrance of the Ulala bay, situated only a few miles to the north; they are represented (l. c. p. 68) by Rink in a section. Further to the north the mostly bare hills on the west coast of Camorta, recalling by their external shape conical volcanic forms, attain a height of from 4 to 500 feet; they no doubt indicate the further extension of the serpentine and gabbro-rocks, which on Camorta and Nancowry are traversed from south-south-east to north-north-west by a longitudinal cleft.

In the interior of the Nancowry haven, wherever the rocks are exposed on the projecting angles, they appear to be well-bedded, whitish-yellow, clayey marls, alternating with banks of a fine-grained sandstone, with serpentine and gabbro tufas.

Most instructive in this respect is the precipitous south-eastern corner of Camorta at which the coast line bends into the Trinkut channel. The argillaceous marl formation is here well exposed in cliffs of from 30 to 80 feet high. On the southern side of the corner the transverse section of the strata can be observed, dipping at 25° to 30° towards west, while on the eastern side, parallel to the longitudinal break, the beds crop out horizontally one above the other. The argillaceous marl does not contain fossils, is of a yellowish white color,

* Gabbro is a rock composed of diallage, smaragdite or hypersthene with labradorite or saussurite, and often some other minerals in an irregular mixture.

and on the perpendicular walls it was covered with inch-long, white, very thin, crystals of a silky lustre. The examination of these showed them to be sulphate of magnesia. The clay itself contains, according to Rink's analysis, besides silicate of alumina, iron-oxide and magnesia.

The whitish-yellow clay marls of Camorta and Nancowry being entirely free of lime have become famous since Professor Ehrenberg (Berl. Akad. Monatsberichte 1850, p. 476), by an examination of the samples brought by Dr. Rink, has shown that they are true *Polycistina*-marls, like those of the Barbados. Ehrenberg discovered in 1848 about 300 species, which were by Professor Forbes believed to belong to miocene (tertiary) deposits. Ehrenberg says: "Especially well developed is this material on Camorta, where, near Frederickshaven, a hill 300 feet high is covered all over with variegated *Polycistina*-clay, while the Mongkata hills on the eastern side of the island are according to Rink entirely composed of a whitish-clay resembling meerschaum; this is, according to my analysis, a nearly pure agglomerate of beautiful *Polycistina* and their fragments, beside numerous *Spongiolites*."* The species of *Polycistina* on the Nicobars are, according to Ehrenberg, the same which compose the similar marl on the Barbados, situated in nearly the same latitude; but there are also some new forms.

Near the level of the sea, the clay marls, which locally contain angular fragments of serpentine and gabbro, alternate with more solid strata of a psephitic rock, which is composed of strongly-cemented angular fragments of serpentine and gabbro, and can therefore be best designated as gabbro-tufa. It is remarkable that this rock again includes larger and smaller pieces of the clay marl. On the eastern coast, near the village Inaka (Enaca) a reddish micaceous sandstone appears between the clay marls.

Similar are the geological conditions on the northern coast of Nancowry. Between the villages Inúang and Malacca, the whitish-yellow clay marls crop out in slightly inclined strata; between Malacca and Injáong, however, lies a precipitous cliff, on which these strata rise almost perpendicular, and are gradually replaced by an accumulation of fragments of serpentine and gabbro. At the projecting corner itself, the traveller faces a precipitous cliff of about 60 feet in height, but being cracked and decomposed, the true nature of the rock is recognised with difficulty. On a fresh fracture, however, one soon observes a massive diallage rock, the laminar diallage being clearly traceable in the nearly solid mass of felspar. Narrow veins of quartz pass through the rock.

From here up to the village Injáong the strand is again flatter, and nowhere nearer than on the other side of the village high, dark-colored, rocks are a second time visible, indicating a massive rock. These are the two places which Rink also has marked on his maps as plutonic rocks.

Trice and Track.—On the north-western point of the small island Trice, highly upheaved banks of a fine-grained argillaceous sandstone of a greenish-grey color form a low precipitous shore. The same stratified rocks alternate with thin-bedded sandy slates, showing on the south-eastern coast margin of the small island Track, only a few cables length distant, the accompanying section. Pl. 4, Fig. 4. Besides a fault, the strata form a saddle and strike from south-south-east to north-north-west. In a sandstone bank I found here imbedded a rolled fragment of a bituminous coal, the same of which I met with a larger but equally rolled fragment on the strand of the island Trice. Of coal seams there was, however, no trace to be detected; what might be mistaken for them from a distance was only the shadow of softer sandstone banks deeply weathered out, or the darker color of some strata.

Pulo Milu.—A small island on the northern coast of Little Nicobar, which Dr. Rink has so excellently described in all its peculiarities, consists, in the higher parts, of a grey, fine-grained, micaceous and calcareous sandstone in massive banks. Very often spheroidal concretions are to be observed showing on the soft weathered surface like cannon balls. No trace of fossils could be found. The massive banks have thin-bedded sandy slates interstratified. The strata strike from south-south-east to north-north-west, dipping to east at an angle of 45 degrees. Dr. Rink (loc. cit, p. 50) mentions a fossil resin in the sandstone of Milu.

* The result of examination of a Nancowry specimen is figured on Plate XXXVI of Ehrenberg's 'Mikrogeologie.'

Pulo Milu was particularly instructive for me, because the dependence of the vegetation on the soil and its geological basis could be perfectly well recognised. The vegetation and the geological formation of the ground stand in the closest relation to each other, as clearly shown by the accompanying sketch plan. The sandstone hills are covered with jungle; the coral (calcareous) ground with high forest trees; the saline, calcareous, sandy ground is occupied by cocoa-palms, and in the fresh water swamp on the declivity of the hill range, which resembles in its curve a horse shoe, thrives the finest forest of *Pandanus* which we have seen on the Nicobar Islands.—Pl. 4, Fig. 5. *Plan of the island of Pulo Milu.* 1, Sandstone with bushy forest; 2, Coral conglomerate, with high tree forest; 3, Coral and shell sand, with forest of cocoa-nut trees; 4, Coast reefs; 5, Fresh water alluvium, with forest of *Pandanus*. Pl. 4, Fig. 6, *Section of same island on line A. B. Fig.* 5.

We have not visited the coast of Little Nicobar, the mountains of which rise to 1,000 feet elevation above the sea.

Kondul—between Little and Great Nicobar,—consists of a hilly ridge, 1½ nautical miles long and ½ mile broad; its strata strike north-north-west., and dip at 70° towards east. The western side is the precipitous one. The strata represent an alternation of more or less sandy or clayey beds. The sandstone predominates, yellowish-white, with ferruginous reddish-brown particles. The clayey beds partly consist of a greasy plastic clay, partly of a crumbling yellowish clay marl, with intercalated thin-bedded sandy slates. The only organic remains which I found were indistinct traces of *Algæ* and small rolled fragments of coal.

Great Nicobar.—What shall I report of Great Nicobar? With the exception of some sandstone hills on the northern coast, and the sandstone ranges on the eastern side of the Galathea Bay in the south, I have not seen anything. Great Nicobar, with its mountains rising up to 2,000 feet, is geologically quite a *terra incognita.*

A very remarkable earthquake, which is said to have lasted from the 31st of October to the 5th December, 1847, on the Nicobar Islands, at which time also earthquakes occurred in the middle and western part of Java, is described from the *Penang Gazette* in *Junghuhn's Java* (part II, p. 940). On this occasion fire is said to have been seen on one of the mountains of Great Nicobar.

Can the highest mountain of Great Nicobar be a volcano? Its form is that of a volcano, but as Junghuhn says that one could land on the southern coast of Java, wander about many days among sandstone and slate rocks, without obtaining through any of the phenomena even a trace of the stupendous volcanic nature of Java; in the same way there may be in the interior of Great Nicobar, rock-formations hidden, of which one does not get an idea along the coast. However, I do not attach any importance to the rumour that fire has been seen on Great Nicobar, though the description of the earthquake seems trustworthy, as I had myself occasion to observe on Kondul the mountain-slips referred to in the account.

These few observations, combined with those of Dr. Rink, give us the following, though probably still very imperfect, idea of the geological nature of the Nicobar Islands.

Among the various geological formations on the Nicobar Islands, *three* are the most important:—1, *An eruptive serpentine and gabbro formation; 2, Marine deposits, probably of a younger tertiary age, consisting of sandstone, slates, clay marls and plastic clay; 3, Recent coral reef formations.*

The serpentine and gabbro formation of the Nicobars is characteristically of an eruptive nature. The tertiary sandstones, slates and clay-marls appear forcibly broken through; their strata are partly inclined, partly bent in flat, parallel, wave-like, undulations. These rocks are accompanied by coarser and finer breccias composed of angular fragments of these same rocks, and they can partly be regarded as friction-breccias, partly as sedimentary tufas in which beds of an argillaceous marl are interstratified. The eruption of these plutonic masses appears, therefore, to fall in a time when the formation of the marine deposits was partially completed, partially still in progress. They broke through, on lines of fracture of which the principal strike from south-south-east to north-north-west agrees with the longitudinal extension of the islands. On the middle islands, the serpentine and gabbro attain their greatest development; on Tillangchong, Terressa, Bompoka, Camorta and Nancowry they form bare hill-ranges of from 2,500 feet elevation, and their configuration often marvellously resembles those of younger volcanic formations. The elevatory power has, however, acted most strongly on the southern islands, and has here upheaved sandstones and slates probably to heights of 1,500 to 2,000 feet above the level of the sea; on the low northern islands the same power was, on the contrary, weakest.

With regard to the sedimentary deposits, I may state that Rink called the argillaceous deposits of the northern islands "older alluvium," and the sandstones and slates of the southern islands "brown-coal formation." In separating them from each other, he considers the former as being derived from plutonic rocks through chemical and mechanical decomposition, and as only of a local character. According to this the archipelago of the Nicobars is divided by him into two geologically different groups,—an opinion with which I cannot agree.

The clays and clay-marl formations of the northern islands, Car-Nicobar, Teressa, Bompoka, Camorta, Trinkut, Nancowry, and the sandstones and slates of the southern islands, Katchall, Little and Great Nicobar, appear to be only petrographically different products of one and the same period of deposition. There are at the same time very few materials from which the age of the marine formations could be determined, as the only fossil remains which have been found in their strata are fragments of *drift wood* changed to brown coal, plant impressions resembling *Fucoids, Foraminifera and Polycistinæ.* But all these remains indicate more or less distinctly a young tertiary age.

The same conclusions are derived from a comparison with the geological conditions of those islands which lie on the same line of elevation as the Nicobars; I refer especially to Sumatra and Java.

I have not the least doubt that the clay-marl and sandstone formation has its perfect analogue among the tertiary deposits of Java, which I had myself the opportunity of studying and comparing in their distribution and lithological character. These became first known through the late Fr. Junghuhn, whose researches on the physical geography of Java are of such merit.

According to Junghuhn, one-fifth of the surface ground of Java is alluvial soil. This is especially prevalent on the northern side of the island, extending from the coast inwards either one, or sometimes five to ten English miles; one-fifth of the island consists of volcanic cones, and their immediate vicinity where the lower rocks are covered up by volcanic products. These conical hills chiefly occupy the interior of the island, sometimes in a double range stretching from west to east; while three-fifths of the area are occupied by tertiary rocks. Either in flat protuberances or in clod-like elevations, these tertiary rocks surround the volcanic range always on two sides, on the southern as well as on the northern. On the northern side, the less highly upheaved tertiary strata underlie the alluvium, and therefore occupy on the surface a small area. In an unequally greater degree, the tertiary deposits are developed on the southern side of the volcano, both as regards height and horizontal extent. They are mostly visible split in clods (schollen) which always rise higher towards one side,—the north, or towards the volcanoes,—and are at their highest edge upheaved to 2, 3 and even to 4 thousand feet. It is also principally on the southern side that plutonic rocks occur in the neptunian deposits of Java, which are occasionally only represented by narrow and sharply defined veins, without any influence upon the structure and configuration of the surface; sometimes, however, they form small hill ranges or isolated hills, similar to the serpentines and gabbros of the Nicobar islands.

According to the reports of the Dutch Mining Engineer, Huguenin,* a repetition of the geological formations of the Nicobars appears to be met with in the Tjiletuk Bay (the southern lateral bay of the Wynkoop Bay on the southern coast of Java). The prevalent formations here are sandstone-conglomerate and highly developed greenstone-breccias, besides plutonic rocks of the greenstone group. From specimens which I had an opportunity of seeing in the local collection at Beutenzorg, I found that these plutonic rocks are serpentines, gabbros and aphanites, exactly similar to those of the Nicobars. Equally identical appears to be the chalk-white clay-marl in the middle portion of Bantan, and the fine white marls in the southern portion of Tjidamar, mentioned by Junghuhn (loc. cit., p. 13), with those occurring on the Nicobar islands.

[1] Naturkundige Tijdschrift voor Nederlandisch Indie, Theil XII, p. 110, 1856.

At the time of my stay in Java (1858), and from all I could find described, as well as from my own observation, I came to the conclusion that in the tertiary deposits of Java two principal groups can be distinguished, setting aside the limestone formation, the proper place of which in the system of Javanese deposits is as yet doubtful:* 1. *A lower coal-bearing group:* numerous workable seams of brown coal are imbedded in quartzose non-calcareous sandstone and slate-clay with silicified stems of trees; marine shells are very rare, or absent. To this I referred the coal seams discovered by Junghuhn in the south-western part of Java, as also the coal formation on the Kapuas river in West Borneo, and the extensive coal districts in Southern and Eastern Borneo, finally the coal of Benkulen (Bencoolen) on Sumatra, and numerous other similar deposits scattered over the Indian Archipelago. 2. *An upper group without coal:* a clay and sandstone formation with plastic clay-slates, argillaceous marls, calcareous sandstone, trachytic tufas, breccias and conglomerates, rich in marine shells, fossil plants, fossil resin, but merely with nests of coal in place of coal seams.

Reasons, which I have given elsewhere,† have induced me to regard this complex group of strata as probably of Eocene age. This opinion may even now stand as regards the lower group, while as regards the upper group, I gladly accept the opinion of my friend Baron v. Richthofen, and the conclusions derived by H. M. Jenkins,‡ from which these fossiliferous deposits appear to be younger Miocene.

I suspect that to this upper Miocene group correspond the tertiary deposits of the Nicobars, although fossils confirming this suggestion have yet to be discovered. It is also beyond doubt that these deposits are not wanting on Sumatra, in certain respects a connecting link between Java and the Nicobars. Junghuhn (loc. cit., p. 8) justly remarks: "The tertiary formation appears to have a sub-marine extent over the whole of the Indian Archipelago, because wherever within this Archipelago the earth's surface rises above the level of the sea, this neptunian formation is observable. I know this for certain as regards Northern Sumatra, where the tertiaries are especially found in the Batta districts (Batta ländern). With the exception of the trachytic island Dungus Nasi all the islands in the Bay of Tapanuli (situated exactly in the prolongation of the Nicobars), besides the adjoining low shores of Sumatra, and partially also the mountains near Tuka, are composed of more or less upheaved sandstone strata, containing, though sometimes rarely, tertiary shells." Thus it appears to be principally on the southern coast of Java and the south-west coast of Sumatra that we find a repetition of the geological conditions of the Nicobars.

The commencement of the eruptive formation is in Java inaugurated by serpentine, gabbro, massive rocks resembling diorite (greenstone trachytes as in Hungary); more or less typical trachytic rocks follow, and the grand volcanic eruption extending up to the present time from the termination of the enormous eruptive phenomena in the Indian Archipelago. At the same time it appears that the eruptive line has been shifted slowly, on Java from south to north, and on Sumatra from south-west to north-east, so that this line would strike east as regards the Nicobar group in the same longitude in which east of the Andamans it reappears on the volcanic Barren Island and Narcondam.

The young tertiary age of the serpentine and gabbro eruptions on the Nicobars and Java has its perfect analogue in the eruptions of the same rocks in Central Italy, which, according to Signor Perazzi, in Turin, and Prof. Savi, are partly Eocene, partly Miocene, and which, on account of their copper ores, are of importance to the miner.

The third principal formation of the Nicobars are coral formations, belonging to the most recent or the present period. Coral banks of great thickness are found on Car-Nicobar, Bompoka and several other islands; they consist partly of a compact coral limestone, partly of a coral or shell conglomerate, upheaved up to 30 and 40 feet above the present level of the sea; on all the islands, the original area is to be observed enlarged by coral-land, which is only separated by the higher sand dunes along the shore, from the still continuing formation of the coral reefs surrounding all the islands in the character of fringing reefs. Although these raised coral banks are a decided evidence, in favor of the long continued

* According to Junghuhn this limestone is the youngest of all the formations, and is always to be found only in superficial banks.

† Reports on the doings of the mining engineers in Netherlands India (Jahrbuch der k. k. geol. Reichsanstalt, Wien, 1858, p. 277).

‡ Quart. Jour. Geol, Soc., London, Feb., 1864.—F. Baron v. Richthofen, Zeitschrift der deutschen geol. Gesellschaft. Bd. 14, p. 327.

upheaval of the islands,—that in connection with the eruption of the serpentines and gabbros,—the formation of the flat coral-land elevated only a few feet above the level of the sea can, on the other hand, be explained by the accumulation of coral fragments, of sand and shells by the waves and breakers on the shallow surface of the fringing reefs. A detailed description of the peculiarities of the Nicobar coral reefs and of the formation of the low coral-land has been already given by Rink. (loc. cit., p. 88, &c.).

II.—*On the occurrence of coal and other useful rocks and minerals on the Nicobar Islands.*

The question regarding coal was the principal point of inquiry during the first expedition to the Nicobars, which was undertaken in 1845 by the Danish Consul *Mackey* of Calcutta, the Englishman *Lewis* and the two Danes *Busch* and *Löwert*.

The solution of this question was a second time the problem undertaken by Dr. Rink, as geologist with the royal Danish Corvette "Galathea." The order of the day No. 5, which contained the instructions and directions for the survey and exploration of the Nicobar islands on the part of the scientific expedition of His Majesty's Frigate "Novara," made the reply to this question my duty also.* The facts on this point are as follows:—

The results of the first expedition were confined to the discovery of single pieces of coal on the strand of the southern islands. Dr. Rink found several localities of coal on different places of Little Nicobar, Trice, Milu and Kondul. "These localities at which coal occurred proved, however, everywhere to be isolated masses varying from one to two inches in thickness." The incorrect (as already stated) designation of "brown coal formation" for the sandstones and slates of the southern island might have been the cause of misunderstanding; but Rink himself (loc. cit., p. 53) expressed his results thus:—"There appears nothing found on the Nicobar islands which would correspond with the coal formations of South-Eastern Asia. The coal localities were met with here and there without any order either in sandstone or in slate, and appear to me therefore to be derived from driftwood which was deposited with the clay and sand. I nowhere found anything which could indicate an accumulation of plants in basin-like depressions, in which the plant would be growing *in situ* and through which the surrounding masses of clay would be impregnated with organic ingredients and mixed with portions of plants. The question, therefore, still remains pending whether those brown coals occur in considerable quantity, as the quantity and size of the collected pebbles would seem to indicate."

I also did not succeed farther than finding single fragments of brown coal. The first fragments were met with on the strand of the small island Trice; it was a brown coal with conchoidal fracture, but still with distinct structure of the wood. The pieces were all rolled, and the largest—5-inches long, 4-inches broad and 2-inches thick—was bored by *Pholadidæ*. I do not doubt that these pieces were derived from the beds of the sandstone or slate of Trice; but on the opposite island Track, I was fortunate to knock out of the sandstone, *in situ*, a small fragment of coal also rolled. Exactly in the same way I also found small fragments of brown coal on Kondul and on the south side of Great Nicobar, partly on the strand, partly on the sandstone or slate rock, and it is certain that these pieces occur all through the group of islands. The condition of all the brown coal fragments met with tends to show that they were only singly imbedded driftwood pieces, which were changed to coal, not that they belonged to large coal seams through the destruction of which they have come into younger strata. Only on the strand of Pulo Milu have I obtained pebbles of true coal with laminated structure, such as is only to be found in seams. It is, however, much more probable that these pieces of coal came from the steamer "Ganges" accompanying the "Galathea" in 1846, and stopping for some time about Pulo Milu, than that they were derived from coal seams on the Nicobars. I therefore entirely agree with Rink's opinion, that so far as it is possible to make observations nothing speaks in favor of the existence of true coal basins on the Nicobars, and that the occurrence of workable coal is not probable. However the area of Great and Little Nicobar is large enough to hide under the thick primeval forest formations of which no trace

* This instruction runs:— According to the report of the naturalists of the Danish expedition, coal and probably also precious metals occur. As far as this may be verified, samples in sufficient quantity ought to be taken equally so in case of metals being found. In general it is however to be reported, as regards geological conditions, how far conclusions can be drawn from the existing rocks as to the occurrence of useful minerals, &c. Of the rivers and springs, the temperature should be measured, &c., &c.

may be observed along the coast. Until the interior of these islands has been examined, the question regarding coal on the Nicobars cannot be answered in any other way than it was by the first expedition.

Equally unfavorable must be the opinion regarding the occurrence of ores or other useful minerals. Nothing of the kind has yet been found on the Nicobars. Gold and useful minerals are partially rich on islands and along coasts which, viewed geologically, belong to the same area of elevation as the Nicobars, as I have already pointed out. The natives who long ago observed those fragments of coal, who use glass pearls, silver fragments, &c., as ornaments, who know the plants and animals of their islands pretty well, and who have for all more common phenomena, for all useful products of the animal and vegetable kingdom special names, these inhabitants have as yet found among the rocks of their islands nothing that they would be able to make use of for ornament or other useful purposes. The only traces of ore which I found were those of iron pyrites and copper pyrites, finely disseminated through dioritic and serpentine-like rocks. The possibility of the occurrence of copper ores in the eruptive formation cannot be denied; however, no discovery has as yet been made which would indicate it. On the other hand, the islands are rich in useful building materials. The sandstones of the southern island must give excellent working stones; the plastic clays of the northern islands could no doubt be equally well worked into bricks or into pottery; the natives of Chowry make large pots of it. Finally lime is offered by the coral reefs in inexhaustible quantity along the coasts of all the islands.

III.—*The soil and its vegetation.*

[Only brief extracts of this section are given.]

Dr. Hochstetter states that vegetation in its original state always indicates the character of the soil, provided the atmospheric conditions are the same. This is, however, on the Nicobars, highly the case. 'Neither the difference in the latitude from the most northern to the most southern islands ($2\frac{1}{2}$ degrees), nor the difference of the absolute elevation (the highest hills on Great Nicobar only attain about 2,000 feet above the sea), is large enough to produce on the single islands, or parts of them, such a difference in the climatal conditions, that on it alone an altered character of vegetation should depend. Rocks, soil and vegetation are, therefore, on the Nicobars in such a degree related to each other, that the areas marked on a map as indicating various rocks would almost coincide with those indicating the varieties of vegetation. Unfortunately the sketching out of such maps for the larger inaccessible islands is impossible; to indicate it I can only attempt a representation of the small island Milu (Pl. 4, Fig 5.) and the north-western bay of Little Nicobar.'

'The results of these observations may be seen in the following tabular view :—

Geological character of the underlying rock.	Character of soil.	Respective character of vegetation.
1. Salt and brackish swamp, damp marine alluvium.	Swampy ground not capable of cultivation.	Mangrove-forest.
2. Coral conglomerate and coral sand, dry marine alluvium.	Fertile calcareous soil; principal constituents, carbonate and phosphate of lime.	Cocoa-palm forest.
3. Coral conglomerate and coral sand beside dry freshwater alluvium.	Fertile calcareous sandy soil.	Large forest trees.
4. Freshwater swamp and damp freshwater alluvium.	Swampy ground, capable of being cultivated.	Pandanus forest.
5. Plastic clay, magnesian clay, marls and partially serpentine.	Not fertile clayey soil; principal constituents, silicate of alumina and silicate of magnesia.	Grassy plains.
6. Sandstone, slate, gabbro, dry river alluvium.	Loose clayey, sandy soil, rich in alkalies and lime, very fertile.	Jungle (the true primeval forest).

'*The Mangrove forest.*—Several deep channels, rich in fishes and navigable by the canoes of the natives, occasionally extend in serpentine turns through these mangrove swamps. One meets not uncommonly at the end of such channels in a hidden locality villages of the natives, as for instance, on Trinkut the pirates' village Dschanoba.' (Janoba).

'The brackish-water alluvium, the ground of the *Rhizophori* and *Cerithia,* must, therefore be considered as a soil perfectly unfit for cultivation. It occupies only a small area as compared with that of the islands, but it is nevertheless of a mischievous importance. For it can justly be said that the Nicobars owe their unhealthy climate principally to these brackish-water swamps, as they occasionally extend for miles from the mouths of the rivers into the interior. In these swampy districts, the change of the fresh to salt water causes a decay of the organisms, which can only exist in the former, the reverse takes place in salt water changing to fresh water. The ebb exposes large areas, and decomposition of the organic life takes place, filling the air with most poisonous miasmas.'

Dr. Hochstetter says that he especially had opportunity of studying these marked changes on a grand scale on the northern coast of Great Nicobar (west of the Ganges harbour). On the other hand, the coral land appears to be fertile, capable of cultivation, and healthy at the same time, and the dry marine and freshwater alluvium, to which on the sea coast belong the cocoa-palm forest, and further inland extending to the back of the hills, a beautiful forest of various kinds of large trees. This is the ground which the natives of these islands have selected for their abode, finding here all the necessaries of life.

The cocoa-palm forest is described by Dr. Hochstetter as the picture of life, and he thinks that if the cocoa-palms had not been there, the islands would have been probably uninhabited up to this time. He further states that, taking the number of the inhabitants of all the islands to be 5,000, there would be about five and a half millions of nuts required for annual use. The annnal export of cocoa-nuts can further be estimated as about ten millions, for Car-Nicobar alone exports between two and three millions. This gives fifteen and sixteen millions of cocoa-nuts to meet the annual demand. On the northern islands, the cocoa-palms occupy comparatively a larger area, while on the southern islands, especially on Great Nicobar, they are nearly altogether wanting. The northern islands are, therefore, the most thickly inhabited, and the cocoa-palms are there divided as property, but on the southern islands they appear to be the free, common, goods of all.

'The Nicobarese not only lives on, but also in, the cocoa-palm forest, having selected for himself not only the most comfortable place for his hut, but being on the dry coral ground, exposed to the current of the wind, also the most healthy situation.'

'*The high forest.*—This is chiefly composed of large trees with rich foliage.' Several valuable timber trees, and others, useful on account of their fruits, are here mentioned.

'The finest high forest I saw on the southern coast of Car-Nicobar.'

'*The Pandanus forest,* in which this remarkable tree suppresses all other vegetation, except a few *Areca-* and *Rotang*-palms, occurs only on the swampy fresh-water alluvium along the course of rivers and streams, especially near the sea where the rivers form more or less permanent basins. Here it is *Pandanus Milore,* the largest kind of *Pandanus,* which forms the forests. I believe that what we saw of the Pandanus forest on Pulo Milu, was one of the most peculiar pictures of tropical vegetation seen during the whole of our journey.'

'The *Pandanus* is not cultivated on the Nicobars; it is most flourishing in a wild state, and is, after the cocoa-palm, the most important plant for the natives as regards food: it is the truly characteristic plant of the Nicobar islands.

'*Grassy plains.*—If one has succeeded in marching from the flat coral-land through the high and *Pandanus* forests, he generally reaches the foot of hills, rising on the larger southern islands, on Great and Little Nicobar to a height of 1,000 to 2,000 feet above the sea, but on the northern islands they are not above 500-600 feet. This hilly land certainly occupies $\frac{3}{10}$ to $\frac{1}{4}$ of the whole area. It is composed of rocks of the gabbro and serpentine formation, and of the clayey and sandy tertiary beds formerly noticed. The eruptive rocks are comparatively of small extent. Where felspathic gabbro forms the ground, this being produced by the decomposition of the rocks may be said to be fertile, it is covered with thick forest, but even the serpentine island Tillang-chong has a flourishing primeval forest. On the other hand, a remarkable difference is perceptible in the vegetation of the tertiary ground.'

'The hills of the northern islands are to a great extent only covered with grass, those of the southern, however, chiefly with a thick forest vegetation. This distinction rests upon an essential difference in the composition of the ground. The hills of the northern islands consist of a sterile argillaceous soil, those of the southern islands, on the contrary, of a fertile calcareous, sandy-argillaceous soil.'

'Where the most favorable tropical climate could produce nothing else, but stiff and dry Lalang-grass *(Imperata)*, and rough Cyperaceæ *(Scleria, Cyperus, Diplaceum)*, surely there nature has clearly enough left the stamp of sterility, yet just between such grassy hills, which from a distance look so homely resembling fields of corn, have the colonists on the Nancowry channel built their houses and gardens. The grass grows now high enough above their burial grounds; the breakers play with the bricks with which they built the houses; gardens and fields, every path has disappeared. On Car-Nicobar I saw these grassy plains partially cut down, because the natives use the grass for thatching their houses, and on Kamorta large strips were in flame.'

The grass vegetation, says Rink (loc. cit., p. 136), which to the greatest extent covers these islands, is, in the valleys at the base of the hills, very thick and high; it becomes however, higher up thinner and shorter. On the places which are sufficiently damp many soft grasses may occur rich in juice; but on the tops of hills, where the dry magnesian claystone locally penetrates through the scanty layers of soil, and is also partially covered with a coarse ferruginous sand, while the showers of rain carry all the finer particles which may be produced by decomposition into the valleys, there, as a rule, only dry and rough siliceous *Gramineæ* and *Cyperaceæ* are to be met with.

The area which may, therefore, in future be successfully cultivated is that of the southern islands, composed of sandstone and slate, producing a fertile argillaceous sandy soil. On Little and Great Nicobar with the small islands Pulo Milu and Kondul, the hilly land may be estimated at nearly two-thirds of the total area. These islands are therefore in point of colonization the most important, and a comparison with Ceylon and Pulo Penang shows what could prosper where now impenetrable primeval forest covers the whole surface.

'*Primeval forest.*—This is of great extent, and the coast inhabitants of Great Nicobar tell of the existence of a wild tribe, forest-men, ("jungle men"), with long hair, inhabiting small huts or trees and living upon honey, roots and game. But no European eye has yet sighted these forest-people.' Dr. Hochstetter describes in vivid language the evermore forest-clad parts of Great Nicobar, which were visited by some of the party along the deeply indented water courses and ravines.

IV.—Springs, Streams and Rivers.

The annual rainfall of the Nicobars is unknown. But very likely it is considerable; I think 100 inches is an exaggeration, because the two seasons, usually distinguished,—the dry one during the north-east monsoons between November and March, and the wet one during the south-west monsoons between April and October,—are not so strictly separated on these islands as on the neighbouring continent, and according to present experience showers are also not rare during the dry season. The driest month of the year may be March. We had, during our stay on and round the islands, in this month only three times rather heavy showers of rain. In April they become more frequent, until in May and June the south-west monsoon rolled constant and heavy clouds over the islands.

If, therefore, peculiar geological conditions do not facilitate a rapid flowing off of the rain, the islands cannot have in general a want of water. And of this we could convince ourselves, inasmuch as the end of the dry season was unfavorable for the quantity of water in streams and rivers. Even the smallest islands, like Pulo Milu and Kondul, though their small streams hardly had any water flowing, still had an abundance of fresh water in the numerous basin-like depressions of their beds. From the forest-clad heights of Tillangchong still rippled out everywhere spring water. The numerous streams and rivers of the southern large and woody islands, Little and Great Nicobar, possess abundance of water all the year round. But the northern island, as far as the argillaceous beds extend, appears to be deficient in water; this specially is the case on Nancowry, Camorta, Trinkut, and probably also on Terressa and Bompoka. I found the small streams on Nancowry and Camorta, leading into the Nancowry haven, perfectly dried up. The natives only drank cocoanut-water, and they probably obtain the fresh water which they require for domestic purposes, &c., like the boiling of Melori, from the fresh water swamps, which are locally to be met with in ravines. Of wells, except that made near the village Malacca on Nancowry and which is now half in ruin, I saw nothing. Car-Nicobar, however, though also composed of argillaceous strata, as the abovementioned islands, has no want of good drinking water, because the large coral land raised from 8 to 12 feet above the level of the sea, permits the digging of those remarkable wells, the fresh water of which falls and rises with the ebb and tide. The explanation of this rare phenomenon does not rest in the filtering of the seawater by the coral-sand, but is rather the fact that the lighter rainwater floats on the heavier seawater, and the porous coral rock only prevents the mixing of the two. I have seen several such rèservoirs on Car-Nicobar near the villages Mus and Saui, they were all dug from 8 to 10 feet through the coral mass nearly to the level of the sea at its highest flood, and contained good drinking water. Besides this, a river flows into the Northern Bay of Car-Nicobar, which we named Areca River from the luxuriously growing Areca-palms on its banks; this river is navigable with flat boats two miles upwards, and near the small rapids which one meets it also offers good drinking water, containing only a small portion of calcareous constituents in solution.

I have not become acquainted with any mineral or warm springs. The clay-marl rocks of the Nancowry haven are, however, seen covered with an inch-thick incrustation of sulphate of magnesia (epsom salts) in fine fibres with a silky lustre; this indicates a quantity of sulphate of magnesia in the clay-marls, and by digging holes in them, epsom salt waters may probably be obtained, such as is the case with the bitter sandy-marls near Bilin in Bohemia.

V.—Observations on the temperature.

As we had, according to our instructions, to measure the temperature of rivers and springs, and as this task fell to my lot, as far as opportunity offered itself, I would put upon record here the few observations in this respect, besides a few remarks on the temperature.

a.—Temperature of the different waters.

1. 23rd February, on Car-Nicobar, water in the well near the village Saui in 8 feet depth in perfect shade	25·7C.
2. 27th February, on Car-Nicobar, Areca river in the shade of the primeval forest ...	25·0C.
3. 4th March, on Tillangchong, western side, a spring in the shade of primeval forest	25·5C.
4. 4th March, on Tillangchong, another spring	26·0C.
5. 8th March, on Nancowry, old well of the Moravian Brothers near the village Malacca, water in 8 feet depth in shadow	25·7,C.

If it were permitted to make from these few observations a conclusion upon the mean of the annual temperature of the Nicobars, this mean would be 25·58C. (=78·04 Fahrt.)

I have also measured the temperature of several other wells and streams, but as their water was temporarily exposed to the sun, very different results were obtained, as for instance:

on Car-Nicobar	
24th February, well near Mus, water in 3 feet depth	27·0C.
25th „ a stream between Mus and Saui	27·8C.
26th „ river near Saui	29·0C.
on Camorta	
9th March, two streams with muddy stagnant water	27·0C.
on Pulo Milu	
18th March, stagnant stream water	26·5C.

b.—Temperatures of the soil.

To obtain further materials for the determination of the mean annual temperature I made a few observations on the temperature of the soil, and these gave the following results:—

8th March, on Nancowry near the village Inuang, the thermometer, after it had been exposed in a permanently shaded place for 6 hours, showed, when buried in 3½ feet depth underground	25·7,C.
20th March, on Kondul, also in 3½ feet after 6 hours	25·3,C.

These two observations give, as did those made in water, an annual mean of ... ... 25·5,C. (=77·9 Fahrt.)

This result is smaller than the records known up to the present, but these also do not rest upon sufficiently decisive observations. Rink, who, during a stay on the islands between January and May 1846, never saw the thermometer under 25°C. and never above 33°C. in perfect shade, believes 28°C. to be the most probable mean.

According to Johnston's Physical Atlas, the line indicating the temperature of the sea surface of 30·5C passes just across the group of islands, the annual isothermal being 26·1C., with the January isothermal of 25·0C, and the July isothermal of 27·2C.

As regards the monthly means, we obtain from the observations of the Danish Corvette *Galathea* every four hours:

for January 1846 ... ... 28·2C.
„ February „ ... ... 28·6C.

According to the hourly observations on board of the Frigate *Novara* the mean is—

For the days 23rd,—28th February 1858 ... ... 27·2C. } mean 27·25C.
„ „ „ 1st,—26th March ... ... 27·5C. }

With this agrees pretty fairly the soil temperature which I measured at a depth of one foot.

On the 26th February near Saui ... ... 27·7C. }
„ „ 20th March on Kondul ... ... 27·0C. } mean 27·26C.
„ „ 26th „ on Great Nicobar ... ... 27·0C. }

Finally, with regard to the daily means, they will be found for the time of our stay on the Nicobars in the observations recorded on board of the vessel. It occurred to me when on Car-Nicobar to see whether the temperature of the water of young cocoanuts, when freshly cut down from a tree standing in shadow, would not indicate approximately the mean daily temperature. I found on the 26th February, in two nuts, a temperature 27·2C. and 27·4C., as a mean 27·3C. The journal kept on board of the Frigate gives for the same day, as mean, also 27·3C.

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ACCESSIONS TO LIBRARY.

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Titles of Books. *Donors.*

ARGYLL, DUKE OF.—Primeval man, 8vo., London, 1869.

BOURGUIGNAT, M. J. R.—Mollusques Nouveaux, Litigieux ou peu connus, 8vo., 1868.

BRONN, DR. H. G.—Klassen und Ordnungen des Thier-reichs. Vol. V, pts. 9, 10, Vol. VI, pt. 4, Leipzig, 8vo. 1869.

BROWN, R.—Miscellaneous Botanical Works of—Ray Soc. Vol. III, 4to., London, 1868.

BROWNE, J. R.—Reports on the Mineral Resources of the United States, Washington, 8vo., 1868. THE AUTHOR.

DODD, GEORGE.—Dictionary of Manufactures, Mining, Machinery and the Industrial Arts, London, 12mo., 1869.

DORNA, PROF. ALEX.—Catalogo delle Leoneidi o stelle meteoriche osservati nel 1867.

GERVAIS, PAUL.—Zoologie et Paléontologie générales, Parts 8, 9, Paris, 4to., 1869.

GOULD, A.—Otia Conchologica: Descriptions of Shells and Mollusks, Boston, 8vo., 1862.

Titles of Books. *Donors.*

HANLEY, S.—Catalogue of Recent Bivalve Shells, London, 8vo., 1842—1856.

JACCARD, A.—Matériaux pour la carte Géologique de la Suisse, Liv. 6. Jura Vaudois et Neuchatelois, with 2 maps, 4to. and fol., Berne, 1869.

KARSTEN, DR. G.—Beiträge zur Landes-Kunde der Herzogthümer, Schleswig und Holstein, I, Reihe, Hft. 1, 4to., Keil, 1869.

MAACK, DR. G. A.—Die bis jetzt bekannten fossilen Schildkröten und die im oberen Jura bei Kelheim (Bayern) und Hannover neu aufgefundenen ältesten arten derselben, Palæontographica, XVIII, pt. 6, Cassel, 4to., 1869.

MARTINEZ, D. M. DE GONGORAY.—Antiguedades prehistóricas de Andalucia, Roy. 8vo., Madrid, 1868.

PHILLIPS, JOHN.—Vesuvius. fcp 8vo., Oxford, 1869.

PICTET, F. J., Matériaux pour la paléontologie Suisse ou recueil de Monographies sur les fossiles du Jura et des Alpes, pt. 4, No. 2, 4to., Geneve, 1869.

PONSON, A. T.—Traité de l'exploitation des Mines de Houille, Vol. I, with folio atlas, Liege, 8vo., 1852.

QUARITCH, BERNARD.—General Catalogue of Books, London, 8vo., 1868. B. QUARITCH.

QUENSTEDT, F. A.—Petrefactenkunde Deutschlands, Vol. II, pt. 1, Leipzig, 8vo, 1868, with atlas.

REID, H.—A practical treatise on the manufacture of Portland cement, with translation of Lobwitz's treatise, 8vo., London, 1869.

SCHIMPER, W. P. H.—Traité de Paléontologie Végétale, Vol. I, Paris, 8vo., 1869, with Atlas.

SOMERVILLE, MARY.—On Molecular and Microscopic Science, 2 Vols., 8vo., London, 1869.

STEWART, J. L.—Punjab plants, comprising botanical and vernacular names, and uses of the trees, shrubs, and herbs, Lahore, 8vo., 1869.

STYFFE, KNUT.—Elasticity, extensibility and tensile strength of iron and steel, London, 8vo., 1869.

VICTORIA GOVERNMENT.—Prize essays, 1860, 8vo., Melbourne, 1861.

WHITNEY, J. D.—Geological Survey of California, Palæontology, Vol. II. pt. 2, roy. 8vo. 1869.

PERIODICALS.

American Journal of Conchology, Vol. IV, pt. 4, Philadelphia, 8vo., 1868.

American Journal of Science and Arts, 2nd Ser. Vol. XLVII, Nos. 139, 140, New Haven, 8vo., 1869.

Annales des Mines, Paris 8vo., 1st Series, Vols. 1 to 13, 1816-26; 2nd Ser. Vols. 1 to 8, 1827-30; 3rd Ser. Vols. 1 to 20, 1832-41, 4th Ser. Vols. 1 to 20, 1842-51.

Annales des Mines, 6th Ser., Vol. XIV, 1868, Vo. XV, 1869, Paris, 8vo. L'ADMINISTRATION DES MINES.

Annals and Magazine of Natural History, Vol. III, Nos. 15, 16, 8vo., London, 1869.

Beiträge zur Geognostischen Kenntniss der Erzgebirge, pt. 3, Freiberg, 8vo., 1869.

Engineer's Journal, Calcutta, New Ser., Vol. XII, Nos. 16, 17, 18, 4to. Calcutta, 1869.

Geographische Mittheilungen, edited by Dr. A. Petermann, Pts. 1, 2, 3, 1869, 4to., Gotha.

Geological Magazine, Vol. VI, Nos. 2, 3, 4, 8vo., London, 1869.

Journal de Conchyliogie, 3rd Ser. Vol. IX, No. 2, Paris, 8vo., 1869.

Journal of Travel and Natural History, edited by A. Murray, Vol. I, No. 6, London, 8vo., 1869.

Malakozoologische Blätter XVI, ½ Bog. (Dr. L. Pfeiffer) Cassel, 8vo., 1869.

Titles of Books. *Donors.*

Martini und Chemnitz, Sytematisches conchylien cabinet, Vol. III, Heft XXVI, Lief. 189, 4to., Nurnberg, 1868.

Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Heft 1, 2, Stuttgart, 8vo., 1869.

Palæontographica, XVIII, 6. Cassel, 4to., 1869.

Palæontographical Society, Vol. XXII, 4to., London, 1868.

Novitates Conchologicæ, by Dr. Pfeiffer, Vol. I, pt. 33, Cassel, 4to., 1869.

Novitates Conchologicæ, Supp. III, Monog. d. Molluskengattung Venus, E. Römer, Pts. 16, 17, Cassel, 4to., 1869.

Poggendorff, J. C., Annalender Physik und Chemie, Leipzig, Indices, 8vo., 1844-54-65.

Professional Papers on Indian Engineering, Vol. VI, No. 23, Roorkee, Roy. 8vo., 1869.
PRINCIPAL, THOMASON COLLEGE.

Quarterly Journal of Science, No. XXII, London, 8vo., 1869.

Quarterly Journal of Microscopical Science, New Series, No. XXXIV, London, 8vo., 1869.

Revue Universelle des Mines, de la Métallurgie des travaux publics des sciences a l'industrie, 12me annèe, Parts 5 and 6, Brux, 8vo., 1868.

GOVERNMENT SELECTIONS, &c. (FROM THE GOVERNMENTS).

BENGAL.—Hill Tracts of Chittagong and the dwellers therein, by Captn. T. H. Lewin, Calcutta, Roy. 8vo., 1869.

„ Report on the results of the administration of the Salt Dept. for 1867-68. Calc., Fol. 1868.

„ Report on the external commerce of Bengal for 1866-67. Calcutta, Fol. 1868.

„ Report on the Financial results of the excise administration in the Lower Provinces for 1867-68, Fol. Calcutta, 1868.

„ Report on the administration of the License Tax under Acts XXI and XXIX of 1867 in the Lower Provinces for 1867-68. Calc., Fol. 1869.

„ Report on the drainage and conservancy of Calcutta, 4to., 1869. Calcutta.

BOMBAY.—General report on the administration of the Bombay Presidency, 1867-68. Roy. 8vo. Bombay.

BURMAH.—British Burmah Revenue Report, 1867-68. Extract from proceedings in the Foreign Department, No. 234. Moulmain, 8vo. 1869.

„ Extracts from proceedings of the Chief Commissioner, British Burmah, in the Home Department No. 264. Vaccination Report, 1867-68. 8vo. Rangoon, 1868.

INDIA.—List of civil officers holding gazetted appointments on the 1st January 1869. 8vo. Cal. 1869.

„ Annals of Indian Administration, 1866-67, Vol. XII. pt. 4, 1868. Serampore, 8vo. 1868.

„ Bibliotheca Indica, Aín-i-Akbari. New Series, No. 157. Calcutta, 4to. 1869.

„ Geographical and Statistical report of the Topographical Survey of Chota Nagpore Division, 1868. Calcutta, Fol. 1869.

MADRAS.—Selections from the Records of the Madras Government. Annual Report on Civil Dispensaries for 1867, 8vo., Madras, 1869.

N. W. PROVINCES.—Selections from Records of Government, North-Western Provinces, 2nd Series, Vol. I, Nos. 3, 4, 8vo., Allahabad, 1868.

„ Selections from the Records of Government, North-Western Provinces, 2nd Series, Vol. II, No. 1, 2, 8vo., Allahabad, 1869.

Titles of Books.	*Donors.*

OUDH.—Selections from Records of Oudh. Carriage for troops, 8vo., Lucknow, 1869.

" Report on the Revenue Administration in the Province of Oudh for year, 30th September 1868. Lucknow, Fol. 1869.

PUNJAB.—Annual Report on vaccine operations in the Punjab for 1868. Lahore, Fcp. 1869.

" Report of the Lahore Medical School for the year ending 31st March 1869. Lahore, Fcp. 1869.

" Annual Report of the Lahore Lunatic Asylum for 1868. Lahore, Fcp. 1868.

" Selections from the Records of the Government of the Punjab and its Dependencies. New Series, No. III, 1869. 8vo,. 1869.

TRANSACTIONS OF SOCIETIES, &C.

BERLIN.—Zeitschrift der Deutschen Geologischen Gesellschaft, Vol. XX, pts. 3, 4, 8vo., BERLIN, 1869. THE SOCIETY.

BRUSSELLS.—Bulletins de l'Académie Royale des Sciences, des lettres et des beaux-arts de Belgique, Vols. 1 to 23, 1832—56.

" Annuaire de l'Académie Royale des Sciences et Belles letters. Bruxelles. 12mo., 1836—57.

" Mémoires Couronnes et Autres Mémoires, Vol. I to XIV, Bruxelles, 8vo., 1840-62.

CALCUTTA.—Records of the Geological Survey of India, Vol. II, pt. 2, 8vo., Calcutta, 1869. THE SURVEY.

" Journal of the Agricultural and Horticultural Society of India, New Series, Vol. I, pt. 3. THE SOCIETY.

" Journal of the Asiatic Society of Bengal, Vol. XXXVIII, pt. I. Nos. 1 and 2. pt. II, No. 2, 8vo., Calcutta, 1869. THE SOCIETY.

" Proceedings of the Asiatic Society of Bengal, Nos. 4, 5, 6, 1869, 8vo., Calcutta. 1869. THE SOCIETY.

" Rules of the Asiatic Society of Bengal, 8vo., Calcutta, 1869. THE SOCIETY.

CHRISTIANIA.—Gaea Norvegica, Parts I, II, III, Christiania, Folio, 1838. ROYAL UNIVERSITY OF CHRISTIANIA.

" Mémoires pour servir á la connaissance des Crinoides vivants, by M. Sars, Christiania, 4to., 1868. ROYAL UNIVERSITY OF CHRISTIANIA.

" Om Underberget ved Kongsberg og om Guldets Forekomst Sammesteds, by Th. Hiortdahl, Christiania, 8vo., 1868. ROYAL UNIVERSITY OF CHRISTIANIA.

DRESDEN.—Sitzungsberichte der naturwissenschaftlichen Gesellschaft *Isis*, in Dresden. Jahr, 1868, Nos. 7, 8, 9, 10, 11, 12, 8vo., Dresden, 1868. THE SOCIETY.

GENEVA.—Mémoires d' l' Institut National Genevois, Vol. XII, Genéve, 4to., 1869.

GÖTTINGEN.—Nachrichten von der K. Gesellschaft der Wissenschaften und der Georg-Augusts Universität aus dem Jahr, 1868, Göttingen, 12mo., 1868. THE SOCIETY.

LISBON.—Memorias da Academia Real das Sciencias de Lisboa, Nova Serie, Vol. I, pts. 1, 2; Vol. II, pts. 1, 2; Vol. III, pts. 1, 2, Lisboa, 4to., 1854-65.

LONDON.—Journal of the Society of Arts and of the Institutions in Union, Vol. XVII, Nos. 847-857, 8vo., London, 1869. THE SOCIETY.

" Journal of the Royal Asiatic Society of Great Britain and Ireland, New Series, Vol. III, No. 2, 8vo., 1868. THE SOCIETY.

" Proceedings of the Royal Geographical Society, Vol. XIII, No. 1, 8vo., London, 1869. THE SOCIETY.

Titles of Books. *Donors.*

LONDON.—Proceedings of the Royal Society, Vol. XVII, Nos. 108, 109, 110, London, 8vo. 1869. THE SOCIETY.

„ Quarterly Journal of the Geological Society, Vol. XXV, pt. I, No. 97, 8vo., London, 1869. THE SOCIETY.

„ Royal Society's Catalogue of Scientific papers (1800—1863), Vol. II, published by Royal Society, London, 4to., 1868.

„ Transactions of the Royal Geological Society of Cornwall, Vol. V, London, 8vo., 1843.

MADRID.—Libros del Saber de Astronomia del Rey D'Alfonso X, de Castilla, Vol. V, pt. 1. Madrid, Imp., 1867. MADRID ROYAL SOCIETY.

MELBOURNE.—Transactions and Proceedings of the Royal Society of Victoria, Vol. VII. 1866, Vol. VIII, pts. 1 and 2 for 1867-68; Vol. IX, pt. 1 for 1868. 8vo., 1868. THE SOCIETY.

„ Transactions of the Royal Society of Victoria, Vol. V, 8vo., Melbourne, 1860. THE SOCIETY.

MOSCOW.—Bulletin de la Société Impériale des Naturalistes de Moscow, Vol. XLI, No. 2, Moscow, 8vo, 1868. THE SOCIETY.

PARIS.—Bulletin de la Soc. Géologique de France, 2nd Ser., Vol. XXV, No. 5, Paris, 8vo., 1869. THE SOCIETY.

„ Mémoires presentes par divers Savants á l'Académie des Sciences de l' Institut Impérial de France, Vol. XVIII, XIX, Paris, 4to., 1868. THE ACADEMY.

„ Mémoires de l'Académie des Sciences de l'Institut Impérial de France, Vol. XXIX. 1867, XXXV, 1866, XXXVII, 1868, Paris, 4to. THE ACADEMY.

„ Comptes Rendus hebdomadaires des Séancés de l'Academie des Sciences, Vols. LV to LXV, LXVII, Paris, 4to. THE ACADEMY.

PHILADELPHIA.—Journal of the Franklin Institute, Vol. LVI, No. 6, 8vo. THE INSTITUTE.

„ Journal of the Franklin Institute, 3rd Series, Vol. LVI, No. 6, LVII, Nos. 1, 2, 3, Philadelphia, 8vo, 1869. THE INSTITUTE.

„ Transactions of the American Philosophical Society, 2nd edition, Vols. 1 to 7, 1789—1809, New Series, Vols. 1 to 9 and 11 to 12, 1818—63. Philadelphia, 4to.

SALEM.—Proceedings of the Essex Institute, Vol. I, 1848—56, Vols. II, III, 1860—63, and Vol. V, Nos. 3 to 8, 1866—67, 8vo., Salem, 1868. THE SOCIETY.

STOCKHOLM.—Kongl. Vetenskaps Academiens Handlingar för 'Ar, 1828, Stockholm, 8vo., 1829, Indices.

TURIN.—Memorie della reale Accademia delle Scienze di Torino, 2nd Series, Vol. XXIV. Torino, 4to., 1868. THE ACADEMY.

„ Atti della R. Accademia delle Scienze di Torino, Vol. III, pts. 2, 3, 4, 5, 6, 7, 8, from December 1867 to June 1868, Roy. 8vo., Torino. THE ACADEMY.

VICTORIA.—Transactions of the Philosophical Institute of Victoria, Vol. II, pts. 1 and 2 for 1857, Vol. III for 1858, Vol. IV for 1859, 8vo. Melbourne, 1860. THE INSTITUTE.

WIEN.—Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe, Vol. XXVIII, Wien, 4to., 1868. THE ACADEMY.

„ Jahrbuch der kais. kon. Geologischen Reichs-anstalt, Vol. XVIII, pts. 3, 4, Wien, Roy. 8vo., 1868. THE INSTITUTE.

Titles of Books. *Donors.*

WIEN.—Verhandlungen der k. k. Geologischcn Reichs-anstalt, Nos. 11—18, Wien, Roy. 8vo., 1868. THE INSTITUTE.

" Sitzungsberichte der Kaiserlichen Akademie der Wissenchaften, Mathematische Naturwissenschaftliche Classe, 1st Division, Vol. LVII, pts. 1, 2, 3, Wien, 8vo., 1868. THE ACADEMY.

" Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, Mathematische Naturwissenschaftliche Classe, 2nd Division, Vol. LVII, pts. 1, 2, 3, Wien, 8vo., 1868. THE ACADEMY.

MAPS, GEOLOGICAL, &c.

RÖMER, F.—Geognostisch Karte von ober-Schlesien, Nos. 7 and 10, Folio, 2 Maps.

HAUER, FRANZ RITTER V.—Geologische Uebersichts-karte der Oesterreichischen Monarchie, Blatt. X, Wien, 1868.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 3.] 1870 [August.

THE MOHPANI COAL-FIELD, by H. B. MEDLICOTT, M. A., F. G. S., Deputy Superintendent, Geological Survey of India.

Sketch-map of 1859.—Any one who has examined with attention the sketch-map of the middle Narbadá region, published in 1859 by the Geological Survey of India, must have noticed how few actual coal-crops are marked in the large area colored as possibly coal-bearing; and more especially, how very partially those outcrops are distributed in that area. With the exception of Mohpani, and the less known case near Lokartalai, all the observed coal-localities occur close to the south border of the basin of stratified rocks, far from the Narbadá valley, on the south tributaries of the Upper Tawa and in the valley of the Pench river. A reference to the index of colours on the sketch-map, and to the descriptive text (Vol. II., Mem., Geological Survey, India,) would suggest possible explanations of these peculiarities: two groups or formations, the Damúda and the Talchir, are mapped under one colour. It was known at the time (see. p. 149, etc.) that the coal is confined to the upper group; but the demarcation between the two is very obscure in this region, and it would have been at that time impracticable to have undertaken to separate them, as no sufficiently accurate map of the country was to be had. Another possible explanation of the anomalous distribution to which I have drawn attention is suggested by the somewhat doubtful boundary between the Damúda group and the overlying strata of the Mahadéva series, as noticed at page 191 and elsewhere—the possibility that some of the latter may have been locally included with the former, thus unduly enlarging the apparent area of the coal-bearing rocks.

It has long been the desire of the Superintendent of the Geological Survey to clear up all these known doubts, more especially with reference to the very pressing question of the coal-supply to the railway that now passes close along the northern margin of this area. The much increased knowledge of all these rocks that has been attained within the last few years will greatly facilitate the final separation of the groups; and thus definite information will be available for the guidance of mining experiments. The detailed topographical survey of this region is now nearly completed; and proof copies before publication of some of the sheets having been obligingly supplied from the Surveyor General's Office, the revision of the geological work was commenced in November last. It will be some time before the detailed examination of so large an area can be completed; but some definite results have been already obtained, bearing very importantly upon the question of the coal-supply and the proper direction for further mining explorations.

Alterations to be made.—To any who have not applied the necessary reservations to the indications of the sketch-map, the present information will be somewhat disappointing. It is still to be expected that coal will be found where it is not now known; but observations made this year greatly reduce the area to which such hopes can be applied with any confidence; the negative indications of the sketch-map have been substantiated by the verification of the surmises that have just been pointed out regarding them. The case may be very briefly stated, and easily understood by a reference to the old map: the whole of the Dhúdhi valley, and all the valley of the Denwa (or Deor) north of the Pachmari range, are formed of rocks belonging to the Mahadéva series,* in which there is no prospect whatever of coal; although it may occur beneath them. A note on the sketch-map indicates the

* In the report under notice the name Mahadéva is used as that of a single group; but recent investigations here and elsewhere tend to show that it comprises several groups, for which collectively the name may perhaps be retained. It would be out of place to discuss the question in the present report.

doubts that were entertained regarding the Deor valley. To the south of the Pachmari range, including a large portion of the plain of the Tawa, the rocks, although belonging to the Damúda series, are certainly higher than the true coal-bearing group of this part of India; they are throughout more or less carbonaceous, and contain the Damúda fossil plants; and there is therefore always a chance of coal occurring in them, as will be fully tested by the detailed survey; but every distinct indication of coal at present known throughout the entire region (with the exception of a poor Mahadéva coal to be noticed presently) is referrible to a thin band at the base of these rocks, immediately overlying the Talchir group, and outcropping near the margin of the basin, as indicated on the sketch-map. This restriction of the apparently large area of the coal-bearing rocks brings into greater importance the limited fields that are known, and suggests the close search for similar small outcrops of the measures along the edge of the basin.

The Mohpani field.—The wide separation, by intervening barren (coal-less) rocks, of the several localities where coal appears at the surface within the large area hitherto generally referred to in this connection as the Narbadá coal-basin necessitates the recognition of as many distinct coal-fields. Of these, the Mohpani field is at present by far the most important, on account of its accessible position, and because the value of the seams has been proved by actual mining. It is situated at the south edge of the Narbadá plains, twelve miles from the Great Indian Peninsula Railway at Garrarwarra, and is traversed by the Sitariva river, in which the entire section is exposed, in a length of about a mile and a half. On the south the measures are buried beneath lofty hills of younger rocks; and on the east, from the sharp bend of the river, the field is rapidly cut off by an overlap of those same strata. To the west the extent of the field is very obscure and doubtful: for seven miles from the Sitariva the ground is very much covered, the talus from the ridge to the south of the measures being confluent with the superficial deposits of the plains, so that only a few small and uncertain outcrops can be seen. A little further west, however, in the Dharajhor, a complete section is obtained up to the metamorphic rocks at the edge of the basin; and the coal-measures are there altogether covered and overlapped, the whole ground being occupied by the younger rocks. Thus the possible limits of the field as appearing at the surface are very restricted; and we have no certain knowledge of it beyond the much smaller area bordering the Sitariva. A description of this locality will be the best guide to the experimental investigation of the rest and of the possible extension of the field by working the measures through overlying formations. The accompanying map, copied from the new Revenue Survey sheets, is not on a sufficiently large scale to express on it the detail that would be desirable for such a purpose; but it will at least make the case intelligible: the little map on the one inch to the mile scale shows all that is visible of the coal-measures in this field; the larger map shows the area over which the measures may outcrop; beyond that area they must be sought through other rocks.

Actual observations very limited.—Although it is now several years since mining was commenced by the Narbadá Company, very little has been done to explore the field; all the workings are on one spot close to the outcrop in the river. Two or three borings were made in the immediate neighbourhood, but without cutting the coal, as will be accounted for presently. The Sitariva Company have been too busy opening their pits, close upon the northern outcrop in the river, to have had time for further explorations. Thus, for a description of the field and its extent there is little more data than that available from the natural outcrops. The extent of this information and of the field as at present known may be judged from the statement that one square mile would very nearly include all the localities where coal is visible; and fully one-half of that square mile is occupied by rocks below the coal-measures. It may indeed be confidently expected that the coal exists and can be followed over a much larger area; but it needs no more at present to show how impossible it would be to arrive at a correct estimate of the extent or value of the field until further trials have been made.

Formations:—There are three formations to be considered: the Mahadéva series, the Barákar group (or the coal-measures), and the Talchir group; besides trap-rock, metamorphic rocks, and the superficial clays and gravels, or 'wash-drift':—

Mahadéva Series.—The Mahadéva series is of great thickness, and comprises a large variety of rocks; but as here exposed, at and near the contact with the coal-measures, it maintains very constant characters, being formed of massive coarse conglomerates, sandy or earthy, and generally more or less rusty; with these are freely but capriciously associated beds of deep red clay sometimes mottled and calcareous, or even with nodular layers of limestone. Courses of rusty sandstone are comparatively rare here. These rocks form the base of the lofty ridge of Nimúgarh, as well as the smaller hills bounding the field on the east;

and they are the last rocks seen at the north end of the section in the river. On the tops of the hills, and generally at a distance from the edge of the basin, the Mahadéva formation is largely composed of sandstones above, associated with earthy beds below.

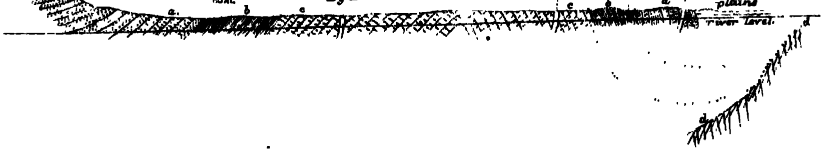
Mahadéva coal.—It is important to notice here the coal that occurs in this formation. Much labor and expense have already been devoted to it; and I am aware that hopes are still entertained of it by intending speculators. Without wishing to deter men finally from exploring what may possibly in some local instance turn out a good thing, it is but right that all should be informed of what is known regarding it. Many thousand maunds of this coal were cut by Mr. Walker, contractor for the Narbadá bridge, at Laméta ghat on the Narbadá, and profitably used for lime and brick-burning. Some was also extracted on the Sher river near Sehora. The same coal has been examined in many other places, as in the Mahanudi, to the north-east of Jabalpúr; in the Hard river, a tributary of the Sakkur; on the flanks of Nimúgarh, south of Mohpani. Many years ago this coal was cut in sinking a well within the station of Jabalpúr. Its characters are everywhere the same,—a bright jetty lignite-coal, disseminated in threads more or less abundantly in thick shale and sandstone; the proportion of coal is exceedingly variable, and, except in rare cases, altogether too small for use. In the nearly continuous rock-section in the Sher and Machariva rivers, this coal is exposed ten or twelve times in a length of as many miles, without any change of character, and offering no encouragement to any attempt at mining. It certainly would not bear transport or keeping; and the most that can ever be expected of it is for local use for rough purposes.

To one who is not familiar with the characters of these formations, and accustomed to discriminate between varieties of similar rocks, this Mahadéva coal-band might readily pass for the true coal-measures, as it often occupies an analogous physical position at the edge of the plains. The simplest criterion is the coal itself, which is quite unlike the Damúda (Barákar) coal. Although found in so many distant localities, the coal-band is certainly not a constant member of the series; nor is it even likely that all the known seams are on the same horizon in the series.

Barákar group.—The Barákar group is not more than 500 to 600 feet thick, composed of strong beds of gray and white felspathic sandstone, alternating near the top with carbonaceous shales and coal-beds. Wherever the section is exposed in the neighbourhood of the Sitariva, these beds are found close beneath the bottom red clays or conglomerates of the Mahadévas.

Talchir group.—The Talchir group is typically characterised by beds of fine greenish silt, or silicious clay and sandstones, in either or both of which pebbles and boulders, often of large size, are thinly scattered. The fine earthy sandstones pass up by imperceptible gradation into the Barákar rock, so that the boundary between them, in the absence of characteristic fossils, must often be arbitrarily assigned. These rocks occupy a large space between the north and south outcrops of the coal-measures on the Sitariva.

Structure of the rocks.—The general section (see figure) north and south across the field will illustrate the relations of the rock-groups and explain the present structure. There is no



General section from south to north, across the Mohpani coal-field.

Scale, 2 inches = 1 mile. *a*, Mahadéva: *b*, coal-measures: *c*, Talchir: *d*, metamorphic.

The dotted lines indicate the probable mode of extinction of the coal-measures to the north.

other locality known where the coal-measures are so much broken as in this field. In the section of the Sitariva, the general character of the disturbance is a normal anticlinal flexure, having moderate dips on the south, but rising to the vertical on the north side of the axis; the last rock seen next the superficial gravels of the plains being vertical beds of the coarse Mahadéva conglomerate. There are numerous minor contortions and dips that are not attempted to be represented in the figure. In an easterly direction from the river, the contortion dies out rapidly; the vertical seams of the northern outcrop flatten and bend southwards, passing round into continuation with the measures on the south of the flexure. The Talchirs are thus covered up at the surface; and, on the other hand, the Mahadévas stretch continuously to the edge of the plains; at Pukuhi they still have a low south-easterly dip, but soon become quite horizontal. In a westerly direction the main feature of the disturbance seems to continue for some distance, as is shown by the steady south-south-east dip of the conglomerate along the base of the Nimúgarh ridge; but this regularity does not obtain along the axis of the flexure, as is shown by the few outcrops that are visible to the north of the ridge. At the west base of the outlying hill of trap near Mohpani, in about the position of the axis of the anticlinal, the coal-measure strata have a steady low easterly dip. This irregularity greatly complicates the attempt to search for such outlying masses of the coal-measures as may exist beneath the superficial gravels at the foot of the hills.

Trap-rock.—Trap-rock forms an important consideration in he valuation of this field. It occurs both in dykes and in overlying masses, but is all of the same description,—a dense basaltic rock; and, as far as present evidence goes, it may be all of the same age. There are three great dykes in the Sitariva: the first is at the very northern edge of the rock-section; it is about twenty yards wide, running through the Mahadéva conglomerate very nearly along the vertical bedding, with a strike of 5° south of west, and a slight southerly underlie. The second dyke is in the Talchirs, oblique to the bedding, some fifteen yards wide, with a strike to 20° north of west, and a slight southerly underlie. The third is also in the Talchirs, about twenty yards wide, running nearly due east and west, and with a very slight southerly underlie. Although all these are remarkably steady for the short length seen in the river banks, they certainly do not continue so, as a rule, for any distance. It is probable that No. 1 represents, or is even continuous with, the strong dyke that is found at or near the base of the hills to the eastwards; but its course must be more or less tortuous. At three miles to the east, in the river's bank just above Dongarkho, there is a very pretty section showing how suddenly these trap dykes may stop out on the rise: at the water's edge the dyke is some twenty yards wide, and all trap; at a height of fifteen feet there is hardly a trace of it to be found, the whole having split up and rapidly thinned out between thick wedges of the overlying massive conglomerate. The dyke No. 3 presents another case of irregularity; if it continued the course which it has in the river, it must have appeared in the upper workings of the Narbadá Company's colliery; but the coal there is totally unaffected by trap. Indeed, it is strange that where trap is so abundant none has been met with as yet in any of the pits, small though these are. There is no doubt, however, that this rock will yet prove troublesome in working the field. Where the coal-outcrop is exposed in the stream beyond the ridge north of the colliery, trap is in force close by, and must greatly affect the coal there.

There are three patches of overlying trap, apparently remnants of a once extensive spread. The detached hill half a mile to south-west of Mohpani is all trap; on the north and east this rock reaches down to the level of the plain; on the south-east Talchir rocks are found close to the base; and on the west side Barákar beds are well exposed to a height of some fifty feet. The trap near Kaklaur and Pipurea scarcely appears above the general level of the plain.

Connexion of the measures on the north and south.—Notwithstanding some slight differences in the details of the sections, and the very marked difference in the quality of the coal, there can be no doubt that the measures worked by the Sitariva Company in the vertical seams on the north are the same as the less troubled beds of the Narbadá Company on the south. There are three or four seams at the southern outcrop, and but two at the northern; and the associated beds do not exactly correspond in the two localities (there are some earthy beds above the coal on the north that are not found in the southern section); but these differences would come well within the known limits of variability of these deposits; and the position of the measures in the general section, with respect to the Mahadévas above and the Talchirs below, is precisely the same in both localities. There is, besides, the direct evidence of continuity; the ground is too covered to show quite an unbroken section, but observations are close enough to leave no doubt on the point. The change in the quality of the coal is quite in accordance with the crushed condition of the strata. The coal from the vertical seams is friable and dusty, and burns without smoke, all the bituminous matter having apparently been extracted from it; it is consequently slow to ignite, but has strong heating power; the coal in its normal state at the Narbadá Company's mines has the usual composition of Indian coals; the subjoined analyses made by Mr. Tween exhibit the change:—

	Carbon.	Volatile.	Ash.
1. Narbadá Company's mines: top seam (river workings)	55·8	32·6	11·6
2. " " " 2 feet band of spurious cannel coal	33·1	24·6	42·3
3. " " main seam	50·4	39·0	10·6
4. " " "	51·9	33·4	14·7
5. Sitariva Company's mines: top seam	67·9	8·8	23·3
6. " " main seam	59·0	15·0	26·0
7. " " "	70·7	9·5	19·8

The Sitariva Company have sunk a shaft on the main vertical east-west seam to a depth of seventy feet, without any change, save a slight tendency to assume a northerly underlie. They have a shaft on the same coal about 200 yards off on the east side of the river, where the seam has already lowered to a dip of 65° to north-north-east. The Narbadá Company's collieries are in a corresponding position on the flat side of the flexure, at the south-east angle, where the strata are bending round the point of the anticlinal; and the galleries bring to sight many minor features of disturbance that could not be detected at the surface. Small as are the workings (the most extensive is about 400 feet long by 150 broad), they are on all sides stopped out against faults; it is true that none of these seem to have any great throw; but their frequency, and the crushing of the coal that attend them, is a serious obstacle and loss. It is to be expected that the coal that exists between the two present collieries is at least as troubled as that seen in the Narbadá Company's pits, probably more so.

Rough estimate of the field so far as proved.—Any estimate of the available coal-supply in this region must be affected by two considerations that do not present themselves in other Indian coal-fields: these are, the frequent high dip of the seam, and the fact that almost at all points thick overlying rocks rise into hills of considerable height close above the outcrop of the coal. Both these conditions will involve the necessity of deeper mining than has yet been attempted in India; in many places here they would restrict the mining to what can be obtained from shafts or galleries on or near the outcrop. Applying this rule to the known length of outcrop in the Mohpani neighbourhood, we may arrive at an approximate estimate of the coal from existing data: it may be said that there are about two miles of known outcrop, the coal being obscurely visible at the surface at several spots along the curved line between the two collieries, *but its thickness or its quality in that position has not been tried.* Assuming it to maintain a mean thickness of workable coal between the aggregates at the two collieries, say twenty-five feet, at the rate of 1,000 tons per foot of thickness per acre of seam, we should have 400,000 tons for every sixty-six feet down the seam along the whole length of two miles. As in many places the seam may be followed for many hundred feet, it is apparent that, without any very unwarrantable assumption, we may count upon a large supply of coal for many years to come.

Probable further extension of the field.—It is, as I have said, unfair to the field to pass an estimate upon it from the very insufficient information at present available; there is much hope that the coal will be found far beyond the limits taken in the estimate just given. I will now attempt to indicate the directions in which an extension may be sought. There are four considerations involved in a judgment: what may have been the original extent of the basin of deposition; how far the Barákar group ever extended in that basin; how far the coal may have been co-extensive with the group; and whether any portion of the group, and hence of the coal which is its uppermost member, had been broken up and destroyed before the Mahadéva deposits succeeded.

already known; and it may be hoped that the measures will rapidly assume a steady low dip, conformable to that observed in the overlying Mahadévas. I have urgently recommended that the seam at the foot of this shaft be followed out southwards, and any fault-ground be thoroughly explored. Machinery is being put up to drain the shaft. The difficulty of unwatering mines in this position is one that must be anticipated: at the base of a high ridge, having a trough-shaped arrangement of the strata, a heavy discharge of water seems inevitable; it is possible that the excessive discharge in this particular shaft may be increased by the proximity of a deep pool in the river just above.

The same indications applicable to other localities.—The indications I have here given to guide in the exploration of the Mohpani field ought to be of service in the search for other fields along the margin of the basin: thus, in the gorge south of Fattehpúr, near Bunkheri railway station, the conglomerate laps round the west end of the ridge of metamorphic rocks, the east end of which is at Khairí; a short way up, the river bifurcates; and just above this there is a small patch of the Talchir boulder bed, surrounded by the Mahadéva conglomerate; it is possible, though not very likely, as this is the lowest level, that outcrops of the Damúdas might be found in the neighbourhood; and similarly elsewhere. It is to settle such points that the detailed survey is so much needed; meanwhile the indications I have given may be of service to independent explorers.

I cannot conclude this report without an expression of regret at the obstructions that are being raised to the development of the Mohpani coal-field. Several years ago mining was commenced with the intention of having the works well opened so as to be in a state to turn out a large supply of coal by the time the railway should be finished; all prospects of profit being necessarily dependent upon that event. The completion of the railway was repeatedly postponed year after year, the mining establishment and plant being necessarily maintained all the time. And now that the main line is opened, and there is a prospect of a return for the outlay on the mines, numerous delays and objections are made to the construction of the short branch line, without which the mines cannot be worked. Questions are still raised as to the relative quality of the coal; upon which point all reasonable doubt has been long since settled; for it may be safely asserted that a large portion of the coal now consumed over the East Indian Railway line is no better than the Mohpani coal. For the Jabalpúr line, and even so far as Naini junction, the Mohpani coal could undersell the Bengal coal, and a considerable saving be made in the railway expenditure. Questions of separate accounts and the desire to show profits on one side or other ought not to be allowed to lead to the public being heavy losers.

1st May 1870.

NOTE ON THE LEAD-ORE AT SLIMANÁBÁD, JABALPÚR DISTRICT, CENTRAL PROVINCES,—by THEO. W. H. HUGHES, F. G. S., Assoc. Roy. School of Mines, Geological Survey of India.

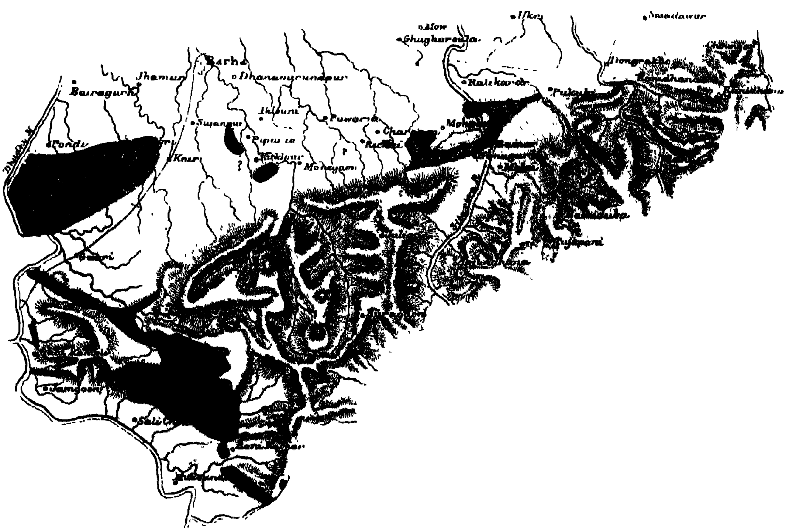
In April last, Mr. Olpherts, Resident Engineer on the Jabalpúr line of railway, announced in a letter addressed to Mr. W. B. Jones, the Deputy Commissioner of Jabalpúr, that he had discovered indications of copper ore about three miles north of the Slimanábád railway station, and expressed a hope that the matter might be further investigated.

Discovery of copper and lead.—Mr Olpherts' attention was first drawn to this subject by noticing some copper stains on the foundation rock of one of the piers for a railway bridge. After making known this discovery, he noted the strike of what he considered the *lode*, and pursuing his researches to the west of the line of railway hit upon another locality—about two miles from the railway station of Slimanábád, and a little off the main road leading to the town, which yielded an ore of lead (galena).

I visited this latter spot accompanied by my colleague, Mr. Fedden.

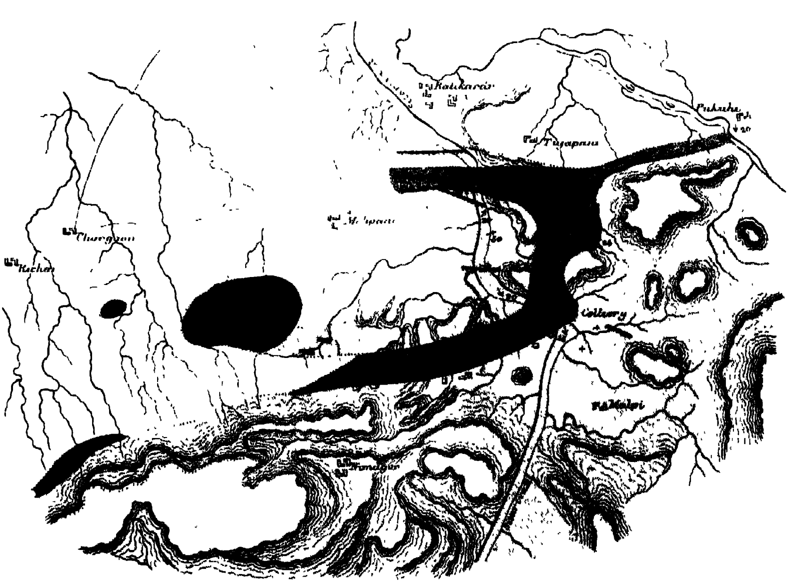
There was very little to be seen, merely a small ridge of quartzite rock, about eight feet in height, forty feet or so in breadth, and a few yards in length, throughout a narrow band of which galena (Pb. S.) was sparsedly distributed, with here and there a little copper pyrites.

Stratigraphical relation of ridge.—A very important point to determine was the stratigraphical relation of this ridge. It did not strike either my colleague or myself that it was a *lode*, but rather a component bed of the geological series which occurs at Slimanábád. The ridge is made up of quartzite, and not of vein quartz; and though many of the hand



MOHPANI AND NEIGHBOURHOOD

Scale 4 Miles = 1 Inch



MOHPANI COAL FIELD

Scale. 1 Mile = 1 Inch

Mahadeva ▭ Coal Measures ■ Talchirs ▭ Metamorphics ■ Trap ■ Dips / Shafts o Boring +

The ground covered by superficial deposits is uncoloured

specimens which I brought away, and others that were in Mr. Olpherts' possession, might possibly convey the idea that the ore existed in a lode, such a misapprehension would arise only from the examination of small pieces of the matrix.

The dip of the bedding is rather obscure, but its direction appears to be 45° south of east. There are planes of jointing striking 20° north of west and inclined at an angle of 75° in a southerly direction.

The strike of the beds is north-east—south-west; so that if this line were followed up, we should most probably find a connection between the two localities where lead and copper ore have been respectively found.

Description of ore.—The ore of lead is galena, a combination of lead and sulphur with a certain proportion of silver. An assay made by Mr. Tween in the Office of the Geological Survey proved the ore to contain 19 oz. 12 dwts. of silver to the ton of lead. The ore of copper is pyrites, which is usually a combination of copper, iron, and sulphur.

At the locality where Mr. Olpherts first noticed traces of copper, the ore is principally malachite, but there appears also to be some dioxide of copper (Cu_2O). From a conversation which I had with Mr. Olpherts, I gathered that the ore was only sparingly distributed throughout the matrix.

Origin of ore in the rock.—The lead occurring in a bed, and not in a lode, it is most probable that it was an original constituent of the rock in which it is now found; and that whilst the rock was undergoing metamorphism the lead became segregated.

Economic value.—In order to form a reliable estimate of the probable richness of this find, I had hoped that a fair amount of clean cut surface would have been exposed for examination, but this was not the case, as Mr. Olpherts, who had the management of the prospecting operations, had not had time to open out enough of the bed.

If the indications, however, of lead at the surface may be taken as a fair criterion of the richness of this quartzite, then I would at once condemn the whole, the proportion of ore to matrix being far too small to make the working of this bed a desirable speculation. It may also be stated that lead ores occurring in beds or nests are usually poor in silver. But it would be premature to pass a final condemnation until further investigations had taken place, and although, as I said above, the indications are unpromising, I would yet recommend that a sum of 2 to 300 rupees should be placed at Mr. Olpherts' command in order that he might carry out to a more satisfactory conclusion the researches which he has initiated.

Incidentally, I may mention that Mr. Olpherts possesses an extensive collection of the various iron ores of the country. Many of these are very rich and occur in great abundance near to and around Slimanábád.

June 1st, 1870.

NOTE ON THE OCCURRENCE OF COAL EAST OF CHHATISGARH IN THE COUNTRY BETWEEN BILASPÚR AND RÁNCHI, by W. T. BLANFORD, F. G. S., Depy. Supdt., Geological Survey of India.

The coal bearing (Damúda) beds of Korba extend for about forty miles to the eastward as far as Rábkúb, in Udipúr (Oodeypore). They also extend far to the south-east towards Gángpúr, and to the northwards towards Sirgúja, and in all probability are continuous or nearly so with the deposits of the same nature known to occur in those districts.

Main Pat with the neighbouring hills and all the country on the road from Main Pat through Chándargarh and Jashpúr to Ránchi consist of metamorphic rocks with the exception of a cap of trap and laterite on Main Pat.

The lateness of the season* prevented my searching to any extent for coal seams, indications of the existence of which were afforded by the occurrence of fragments of coal in the rivers, especially in the Mánd. I found a few seams near Chitra, twelve miles west of Rábkúb and nearly thirty east of Korba. Two or three are seen in the Mánd about three to four miles east-north-east of Chitra, but they are only from a foot to eighteen inches in thickness. In a small stream, the Kopa Naddi, which runs south of Chitra, one seam, about three feet in

* After the end of April I had still 250 miles to march to Hazáríbágh.

thickness, is seen near the village of Tendúmúri, more than a mile south-west of Chitra. It is nearly horizontal, having a very low irregular dip to the west or south-west. Part consists of fair coal, the remainder is shaly.

The only seam examined from which it is possible that a useful supply of fuel might be obtained is exposed in the same stream rather nearer to Chitra, being about a mile from that village, close to the boundary of the village of Tendúmúri. It is very badly seen, but appears to be of considerable thickness, perhaps twenty feet. The upper portion is so much decomposed that no trustworthy estimate could be formed of the quality without digging into the seam: the lower portion appeared to be fair in places. The dip is about 15° to north-north-west.

The villagers, as usual, would give no information, so that I could only trace out the coal seams by the laborious process of searching the beds of the streams, and from want of time I was unable to ascertain whence the greater portion of the fragments seen in the Mánd were derived; but when passing through Ránchi, Lieutenant Sale, in charge of the Chota Nágpúr Topographical Survey Party, told me he had found a seam of coal about four miles north-west of Rábkúb in a small stream running into the Mánd, and it is probable that this may be the source of the blocks I saw in the river bed.

I should add that several coal localities have been lately found by the officers of the Topographical Survey and recorded in their maps. They are all north of Korba and Udipúr.

When passing through Jashpúr, the Rajah told me that coal has been found in his territory in the Khurea country, twenty-four miles north-west of Jashpúrnagar. This would be about 100 miles, or rather more, west by south of Ránchi.

Calcutta, 31st May 1870.

NOTE ON PETROLEUM IN BURMAH, &c., by WILLIAM THEOBALD, ESQ., Geological Survey of India.

Two very distinct sorts of earth-oil are met with in the countries lying to the eastward of the Bay of Bengal, *viz.*, the limpid oil of Arakan and the viscid oil of Burmah, which last is commercially known as the Rangoon oil from its port of shipment, though really obtained at the Yenán-khyoung and other wells in Upper Burmah. The limpid oil of Arakan varies in tint from pale yellow to deep sherry brown, with a peculiar opaline tinge, something like that produced in alchoholic fluids by the presence of fusil oil in excess. The Rangoon oil, on the other hand, is of very uniform color, a peculiar yellowish green and of tarry consistency.

I may here remark that the only other Indian oil I am acquainted with is that produced in the salt range in the Punjáb. This oil is of a consistency almost intermediate between the Arakan and Burmah oil, and differs in tint from both, being brown, devoid of the peculiar greenish hue of the Rangoon oil, and of a decidedly reddish color by transmitted light.* The wells producing the limpid oil are situated near Kyoukphoo, Ramree, and the neighbourhood, and are all confined to the western side of the Arakan range, and none of them occur at any great distance from the coast, whilst the viscid oil of commerce is similarly confined to the eastern side of the same range, occurring most plentifully in Upper Burmah, but met with here and there in very sparing quantity as low down as the parallel of Myanoung.

Of the mode of occurrence of the Arakan oil and of the rocks with which it is associated little is known. The wells are mostly shallow, almost superficial, and would seem only to yield sufficient oil for local use, though their productive capacity has probably never been fairly tested.

The Burmese oil is worked much more energetically, though the geological relations of the oil are little better known than in Arakan. Some of the Yenán-khyoung wells are, I am informed, sunk to a depth of 100 or 150 cubits, first through a little surface clay and then in soft sandstone. The age of these beds is not precisely known, but analogy would point to the nummulitic formation as being the source of these oils. In the Punjáb, the oil rises through contorted beds of nummulitic limestone, and is there in all probability derived from thick beds of carbonaceous shale with lignite, which are associated with and underlie the nummulitic group. As the nummulitic group is largely developed in Burmah, we may, in default of any precise information on the subject, refer in like manner the Burmese oils to the same group.

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* Dr. Oldham has drawn my attention to a remark of Mr. Wynne, that the oil obtained near Rawul Pindi is green, when it issues to the surface. The distinction, therefore, drawn by me between the color of the Punjáb and Rangoon oils would seem to depend mainly on the relative length of time either has been kept, and does not seem, as at first inferred, to originate in any essential difference of composition.—W. T.

In the province of Pegu no nummulitic rocks occur at the surface east of the Irawadi, which entire region is occupied by a newer group of miocene age or younger, and no petroleum well is authentically known within this area. A little below Namián there is a tradition of petroleum having once been known to occur, but I visited the spot and could detect nothing to countenance the rumour in the appearance of the sandstone or any of the neighbouring rocks. The occurrence of oil, therefore, east of the Irawadi in Pegu must be held to be an open question.

West of the river, the only situation where petroleum is known to occur which I have as yet had an opportunity of visiting, is the newly discovered locality at Padoukbeen west of Thaietmio. The well was here sunk to a depth of about twenty feet in soft argillaceous sandstone, rather tender and incoherent and of a dark bluish color, drying paler. The beds in the neighbourhood are shales and sandstones of the miocene series, dipping at low angles and very little disturbed, and not in the slightest degree altered. The oil seems to have been discovered by its saturating the soft sandstone where cut by a small stream in the bed of which the well is sunk, the top being a little way up the bank, but the well being carried below the level of the bed of the stream. Whether the well continues to yield, I cannot say. At my second visit it was abandoned and dry, but I hear it has again been worked. The oil from this spot is precisely similar in every respect to the commercial or Yenán-khyoung oil, and is regarded as equal to it in value by the natives.

There is no indication at this spot of any fault, and the chances of improving the supply by a deep boring are hardly greater than of failure, as there is so little to guide the judgment as to the source of the oil, and as these beds are, I believe, high in the series to which they belong, a very thick set of unproductive beds would have to be passed through, unless the bore struck a seam containing sufficient oil to constitute a flowing well, the presence of which is by no means assured by the insignificant surface indications.

NOTE ON THE PETROLEUM LOCALITY OF SUDKAL, NEAR FUTTIJUNG, WEST OF RAWUL PINDI, PUNJÁB, by A. B. WYNNE, F. G. S., Geological Survey of India.

The petroleum at this place occurs (as usual in the Punjáb, *vide* Geological Reports, Asiatic Society, &c.,) in the nummulitic tertiary rocks. Just near the petroleum pits, as well as to the north and south, fossils occur, orbitolites being by far the most numerous, but bivalve shells in a fragmentary state, teeth of sharks, and large bones are also to be found.

The pits, only one of which is of any depth, are situated in a small open space a couple of hundred yards wide from north to south, covered with superficial debris, and bounded in these directions by rocky ridges of slight elevation. To the east and west are the sources of some of the numerous steep ravines which intersect the country everywhere.

The tertiary rocks on both of these ridges are much contorted along narrow axes, but still possess considerable regularity of strike in a direction about 10° north of east and south of west. They dip at high angles, varying from vertical to 50° or 60° generally west of north and east of south, but lower angles and horizontal beds may also be observed forming parts of curves in the same neighbourhood.

The rocks consist mainly of gray grits and sandstones, with some bands of gray fossiliferous limestone interstratified with thick zones of red shale.

In the immediate vicinity of the pits the strike of the rocks changes to about north-east; they dip at very high angles to the north-west and seem to run against a mass of red shales within a few yards of the principal sinking, being perhaps faulted, but the relations are almost entirely concealed by the covering of superficial debris.

To the southward of the present works within a few feet dark brown shales and sandstones impregnated with petroleum are exposed by an open 'drift' or 'stope' (cut apparently to seek the most productive band), and these as well as a band of limestone in places saturated with the oil may be traced for a few yards north-eastwards, where a quantity of the oil seems to have exuded from the rocks and mingled with the surface soil.

Owing to the abandoned state of the works at present and the insecure gear at the pit's mouth, it was not found practicable to descend, but as the pit is only twenty or thirty feet in depth, the oil could be seen trickling from the highly inclined strata forming the sides, and which dip at the upper part of the pit north-west at 70°. A 'dhol,' lowered quietly and drawn up as rapidly as possible to avoid loss by reason of its leaky condition, contained about seven or eight vertical inches of the oil floating upon clear water, this being rather less than the probable depth of that in the pit, which had been accumulating for three or four months.

It was stated by a native in charge of the place that the oil ran slowly and coagulated in the cold weather, in consequence of which the works had been temporarily stopped, and that when in operation about one maund of oil daily could be obtained. The colour of that taken from the pit was green, but some found in a neighbouring shed was of a dark brown tinge, and burned readily with dense black smoke.

It is understood that the mineral oil procured from here is to be used in lighting the station of Rawul Pindi with gas. A 'gas house' was seen in course of construction there, and large gas mains lie along some of the roads, so that the question of supply becomes of importance: the quantity reported to be obtainable seems so far from encouraging that I doubt whether some larger prospect must not have existed before an expenditure upon gas pipes, &c., was sanctioned.

The locality where the oil occurs is evidently of but limited extent near the village of Súdkal, and it would appear necessary, in order to develop its resources, to open much more extensively, across the run of the beds, trenches cut downwards to the rocks, which are now so much concealed just near the pits. Even if this was done and other pits sunk, there is no reason to suppose any of them would be more productive than the present shaft, and so far as can be judged from what is visible there is not room for many.

As to the possibility of an increased quantity of the oil being obtained by deepening the existing shaft, it can only be said that as the beds are nearly vertical with some underlie north-westward, if these relations are preserved, the pit in depth ought to pass through the beds at present yielding the oil and to enter those seen at the surface in the drift south of the pit, where it may be presumed the prospect of finding the oil in sufficient quantity was less favourable, or the shaft would have been sunk there. As the bedding of the rocks is much disturbed their continuing to lie in the same position for any distance cannot be calculated upon, but it seems likely that (if it has not already been done) the shaft might with some advantage be carried down to intersect the oil-bearing rocks south of the pit.

To sum up: from what is now to be seen at this petroleum locality, it would be advisable to extend the search further before building hopes upon the place as a source of supply for lighting Rawul Pindi, and the quantity said by the man in charge to have been obtained from the present sinking would hardly warrant expectation that sufficiently large results would be obtained by opening other shafts in the same neighbourhood.

On the occurrence of argentiferous Galena and Copper in the district of Mânbhúm, south-west frontier of Bengal,—by V. Ball, Esq., B. A., Geological Survey of India.

Although the greater portion of the district of Mânbhúm consists of metamorphic and sub-metamorphic rocks*, both, but especially the latter, likely to contain ores of the useful metals, hitherto no discoveries of the existence of any appear to have been recorded.

The occurrence of gold in the streams of Mânbhúm and the adjoining districts has, however, long been known. Its mode of occurrence has already been described in these pages†.

During my geological examination of Mânbhúm, the discovery of galena or lead ore was made in the following manner:—When at Dadka, a large village forty-five miles south-south-east of Púrúlia, which is the sudder station of Mânbhúm, the *Ghatwal* brought to me a small piece of galena which had been given to him a few years before by some *Kumars*. He did not know what it was, but used some of it instead of *Surma* or antimony for the purpose of anointing the eyes of his female relatives.

By enquiry from the *Kumars* of the neighbourhood, I was, after several failures, at length enabled to trace the source from whence the galena had been obtained. The lode, for it proved to be such, had been struck some years previously by some *Kumars* who were searching for iron on the side of a hill formed of mica schist, in which there are a number of

* Slates, quartzites, schists, &c. † Records, 1869, II.

veins or small lodes filled with brown hæmatite. This hill is close to a *dih* called Jani-jour, where there is an outlying house of the village of Dekia, which lies about a mile east from Dadka.

I could not ascertain that the *Kumars* had met with galena in any other part of the neighbourhood, though excavations for iron were plentiful.

Having found traces of galena on the surface, I proceeded to excavate, and soon obtained a number of fine specimens of the ore. It occurred quite independently of the bedding of the schists, sometimes in lenticular masses five or six inches long surrounded by quartz, and sometimes in a gangue principally composed of brown hæmatite and quartz; these appearances justify the conclusion that this is a case of a true lode. Owing to the excessively jungly and broken condition of the ground, I was unable, during the period of my brief visit, to trace the lode for any distance, and for the same reason I was unable to ascertain its exact width. Although, therefore, much remains to be ascertained regarding it, still, so far as it has been examined, the indications may be affirmed to be promising. All who have given the least attention to the history of mining are aware of the capricious character of lodes, and of the impossibility of forming even an approximately correct opinion as to the value of any particular one—which is not laid open by a natural section—until some outlay for excavation has been incurred.

In addition to the fact of the existence in any part of this country of such an ore as galena—supposing it to be in quantity—there are many collateral questions and conditions to be considered and ascertained before the commercial value can be properly estimated; of these the most important are the presence or absence of other valuable ores or metals in association with the principal, the abundance and quality of labour and fuel to be obtained on the spot, the means of carriage with the distance of the nearest mart, and, perhaps, not of least importance, the healthiness of the locality.

With regard to the first question, the assay of some of my specimens by Mr. Tween has proved the presence of silver in the unusually large proportion of 119 oz. 4 dwts. 16 grs. per ton of lead*. The assays of most other Indian galenas have given a much smaller amount than this. In Europe, from 35 to 40 oz. per ton is considered quite above the average yield, and argentiferous galena containing very much smaller amounts is frequently worked for silver with profit.

Mr. Tween has also ascertained the presence of antimony in combination with the lead.

Regarding the amount of coolie labour to be obtained, I have no hesitation in saying that it would be abundant. Such was found to be the case in Singhbhúm, when the Copper Company was at work there.

Of the fuel, it is not easy to speak with so much confidence: undoubtedly there is a very considerable amount to be had close by, as the locality is almost in the centre of the heaviest tree jungle in Mânbhúm; but all experience goes to show that such a source of supply is very precarious and uncertain. Possibly it might be found more economical to transmit the ore—should it ever be worked—to the neighbourhood of coal, rather than to attempt smelting on the spot.

The means of carriage are indifferent, or rather bad. Dadka is connected with Púrúlia by a partially finished road, without bridges, which was commenced during the famine. From Púrúlia to the Barákar Railway Station there is a road which has for many years been in the hands of the Public Works Department, but is still far from finished. The distance by these roads is about ninety miles. From Dadka to Midnapore *viâ* Silda, the distance over bad roads would be about seventy miles. From Midnapore the ore or metal might be sent by canal to Calcutta.

The climate is not generally considered healthy for Europeans; still there are many worse places in the district. Doubtless the removal of the heavy jungle would ultimately produce a beneficial effect.

The nearest locality to this at which lead has been discovered is at Hisato in Chota Nagpúr. The antimonial galena from that locality has been described by Mr. Piddington.† From the first specimens sent to him by Major Ouseley he obtained silver in the proportion of 70 oz. per ton of ore; but other specimens subsequently received did not contain a trace of silver.

* This proportion may possibly not be constant throughout.

† Jour., Asiat. Soc., Bengal, XI, p. 892; XII, p. 736, XV, p. 64.

COPPER ORES.

Copper ores have been discovered in two localities in Mánbhúm. The principal is situated on the crushed and faulted junction of the metamorphic and sub-metamorphic rocks about one mile north-east of the village of Poordah, Pergunnah Mánbazaar, or about thirty miles from Púrúlia.

The rock in which the ore occurs is a coarse mica schist, which is traversed by numerous veins of quartz. Whatever the amount or quality of the original ore may have been which existed near the surface, it has nearly all been removed by natives, slight stains of the carbonates of copper on the schist and quartz debris alone remaining to indicate the object for which the numerous excavations which occur along the outcrop have been made.

These ancient excavations at the time of my visit were filled up, some with water, others with debris, which circumstance, coupled with the fact of the ore having been removed, rendered it difficult to form a decided opinion as to the precise nature of the deposit. Subsequent examination of the numerous and often well-exposed copper ore deposits of Singhbhúm*, which appear to be of mixed character (generally the ore occurs disseminated through regular beds of schist; but departing from this rule, it occasionally occurs in true lodes), has induced me to believe that these ill-seen Mânbhúm ores also occur in a two-fold manner. It is possible that the copper-bearing beds of Mânbhúm may belong to the same Geological Zone as those of Singhbhúm; but there are arguments against, as well as for, this view. The whole question must be treated in greater detail than is now possible.

The second locality at which copper occurs is near the village of Kulianpúr, or about thirty-two miles due west of that just noticed. It is on a small hill formed of schists and quartzites, which in one place are stained and encrusted with the carbonates of copper. There is an ancient excavation on the south flank of the hill. So far as it is possible to judge, the deposit seems similar to No. 1. It is not improbable that the ore may be found further westwards, but I did not succeed in obtaining any trace of it in the section exposed in the Subanrika river. There is a small quantity of slag at the bottom of the hill, which indicates that the ore which was found here was smelted on the spot.

The small indications of ore to be seen at the two localities mentioned above are certainly not sufficient to justify any expenditure for excavating, more especially as the attempts to work the similar, but vastly more extensive copper deposits of Singhbhúm, have not hitherto proved to be remunerative speculations.

Various rumours of the occurrence of ores of tin and copper in different parts of Mânbhúm have from time to time been promulgated; but the supposed ores of the more valuable metals have generally proved to be either some form of iron ore, the green mineral epidote, or a bronze-coloured mica.

30th June 1870.

DONATIONS TO MUSEUM.

April 2*nd*.—Specimens of salt from the Sambur Lake. R. M. ADAM, ESQ.

„ 25*th*.—Specimen of petrified grass (rushes) from Java. MRS. BANZIGER.

May 1*st*.—Two earthen pots from the Andamans and Nicobar Islands, a few stone implements, and fragments of pottery from the Andamans.
FERD. STOLICZKA, PH. D.

„ 1*st*.—A cup carved in serpentine from Skardo, Little Tibet. Ditto.

„ 2*nd*.—Twenty-one ornamental (carved and moulded) bricks from Kishnagurh.
MRS. WOOD.

June 13*th*.—A perfect crystal of oxide of iron, pseudomorphic of iron pyrites, from the foot of Sinawur hill, at head of the Suddoom valley.
CAPTAIN T. T. CARTER, R. E.

„ 29*th*.—A complete series of tools, used in South Staffordshire for sinking colliery pits and for working coal and ironstone. S. MINTON, Esq., DUDLEY.

* A description of these will appear in a future number in the map accompanying which the position of the lead ore will be indicated.

In addition to the above, we have received many specimens of various kinds for assay, or examination, among which some of the more important were of iron ores from various localities.

The results of a recent search in the neighbourhood of Hazáríbágh yielded to Dr. Coates and Mr. Donaldson a considerable variety of ores, the principal of which were from the Káranpúrá coal-field and its vicinity, examined sometime since, but not published from want of a correct map. The following numbers show the percentage of metallic iron contained in each. Of course this is the full percentage, and this proportion would not be obtained in manufacture. As the details of these researches will be given elsewhere, we only give the localities and percentages here :—

Belhargadhá	30·6	per cent. of iron.
Chépojúgra in the Káranpúrá valley ...	56·8	„
Muraí Kalan	16·4	„
Gondalpúra	37·3	„
Áráhárá stream	42·12	„
Áráhárá village	11·2	„
Seam 12 feet thick in Damúda	25·6	„
Mándú	33·8	„

A specimen, found loose, to the north-west of Hazáríbágh yielded 68·7 per cent. With the exception of this, which is magnetite, and of the Belhargadhá specimen, all the others are varieties of clay-ironstone.

From the Wún District, East Berar, the Deputy Commissioner forwarded several ores for assay. Some of these were fine rich brown hæmatite traversed by crystalline veins of the pure mineral; these varieties were assayed, yielding, respectively, 60·4, 56·3, and 44·0 per cent. of iron. If with these we take the percentage of the pure limonite, we will have—

$$\begin{matrix} 63{\cdot}2 \\ 60{\cdot}4 \\ 56{\cdot}3 \\ 44{\cdot}0 \end{matrix} = \frac{224}{4},$$ or an average yield of 56 per cent. of metallic iron. There are distinct traces of phosphorus. These specimens were from veins of segregation traversing the beds; but some of the beds themselves are rich and useful ores yielding 48·0 and 45·8 per cent. of iron.

In the immediate neighbourhood of these ores heaps of old slag are scattered over the ground. These slags, the result generally of very crude and inefficient methods of smelting, often contain a very large dose of iron, and it was interesting to examine them. Two specimens were assayed; and one yielded 38·0, the other 34·8 per cent. of iron—an amount which would be ample to pay for re-smelting these slags in conjunction with other ores.

In the Yenak hills, which occur west of the village of that name, near the river Paíngangá, in the southern part of the Wún District, East Berar, Mr. Hughes and Mr. Fedden, during their recent examination of the country, traced over an extent of some five to six miles in length two thick beds of conglomerate (nowhere less than nine feet) containing a large proportion of rolled lumps of a very rich hæmatite. This on assay yielded no less than 68·5 per cent. of iron with a trace of phosphorus—no manganese.

All these are rich and valuable ores of iron and occur in large abundance. The noted hill from which much of the ore smelted by the natives in North-Eastern Chanda is derived, the Lohara hill, near Bissanpúrí, is one mass of iron-ore of a couple of miles in length. A specimen brought by Mr. W. T. Blanford proved to be nearly pure specular iron with a proportion of magnetic iron, and yielded to assay 70 per cent. of metallic iron!

ACCESSIONS TO LIBRARY.

From 1st April to 30th June 1870.

Titles of Books. *Donors.*

Arbeiten der geologischen section für Landesdurchforschung von Böhmen, Royal 8vo., Prag, 1869.

Barrande, J.—Système silurien de la Bohème, Vol., VI, 1 Texte, Distribution, Pt. 2, Planches, 351-460, 4to., Prag.

OUDH.—Records, Government of Oudh, in Public Works Department, No. 20. Progress Report of Forest Administration in the Province of Oudh for 1868-69, flsc., Calcutta, 1870. GOVT. OF OUDH.

„ Report on the condition and management of jails in the Province of Oudh for 1869, flsc., Lucknow, 1870. GOVT. OF OUDH.

„ Report on the Police Administration of the Province of Oudh for 1869, flsc., Lucknow, 1870. GOVT. OF OUDH.

PUNJAB.—Selections from the Records of the Punjab Government, No. VII, 8vo., Punjab. GOVT. OF PUNJAB.

TRANSACTIONS OF SOCIETIES.

BERLIN.—Monatsbericht der konigl. Pruss. Akad., January to April 1870, 8vo., Berlin, 1870. THE ACADEMY.

CALCUTTA.—Journal Asiatic Society of Bengal, Vol. XXXIX, Part I, No. 1, Part II, No. 2, 8vo., Calcutta, 1870. THE SOCIETY.

„ Proc. of Asiatic Society of Bengal, Nos. IV and V, 8vo., Calcutta, 1870. DITTO.

FLORENCE.—Bollettino Comitato Geologico d'Italia, Nos. 2 and 3, 8vo., Italy, 1870. DITTO.

LAUSANNE.—Bull. de la Société Vaudoise des sci. naturelles, Vol. X, No. 62, 8vo., Lausanne, 1869. THE SOCIETY.

LONDON.—Journal of the Society of Arts, Vol. XVIII, Nos. 897-911, 8vo., London, 1870. THE SOCIETY.

„ Proceedings of the Royal Society, Vol. XVIII, Nos. 116-118, 8vo., London, 1870. THE SOCIETY.

„ Quarterly Journal of the Geological Society, Vol. XXVI, Pt. I, No. 101, 8vo., London, 1870. THE SOCIETY.

„ Proceedings of the Royal Geographical Society, Vol. XIV, No. 1, 8vo., London, 1870. THE SOCIETY.

PALERMO.—Giornale di scienze naturali ed economiche del consiglio di Perfezionamentodi, Palermo, Vol. V, Fasc., 3 and 4, Part I, 4to, Palermo, 1869.

PARIS.—Bull. de la Société Géologique de France, 2nd Ser., Vol. XXVI, Nos. 4 and 5, 8vo., Paris. THE SOCIETY.

„ Annales des mines, 6me. Ser., Tom XVI, Livr. 5, 6, 8vo., Paris, 1869.

PHILADELPHIA.—Journal of Franklin Institute, Ser. 3, Vol. LVIII, Nos. 5, 6, 1869, Vol. LIX, Nos. 1-2, 1870, 8vo., Philad. THE INSTITUTE.

ST. PETERSBURG.—Bulletin de l' Acad. Impériale des Sciences de St. Petersburg, Vol. XIV., Nos. 3 and 4, 4to, St. Petersburg.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

VOL. IV, Part 3.

1871.

CONTENTS.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1871. [August.

Report on the progress and results of borings for coal in the Godávarí Valley near Dúmagúdem and Bhadráchalam, *by* W. T. Blanford, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The occurrence of fragments of shaly coal in the bed of the Godávarí close to the spot where the Tál river joins it from the north, about twelve miles above Dúmagúdem, has been known for several years. It was noticed by Mr. Wall in his report of his journey to Kota near Sironchá in 1857, and the coal was by him supposed to be derived from the Tál river. An examination of the Tál for a considerable distance above its junction with the Godávarí, however, having proved fruitless, Colonel Haig, the Superintending Engineer of the Godávarí Navigation Works, asked me to examine the spot when I was marching down the valley in May 1867. I found that in the Tál, near its junction with the Godávarí, the only rocks exposed belonged to the Tálchír group, whilst the Damúdá shales and sandstones, which alone have been hitherto found in the Indian Peninsula to contain coal, appeared at the spot where the smaller stream joined the Godávarí, and I suggested that the coal probably came from a seam buried beneath the sand of the river, and advised exploration by digging away the sand and closely examining the rocks. This was done by Mr. Vanstavern, Executive Engineer, and resulted in the discovery of coal in four places, all a little lower down the river than the mouth of the Tál, so that the bed from which the fragments first found were derived has not yet been detected, but as a large quantity of silt and sand has been accumulated near the mouth of the Tál of late years, it is probably now covered to a considerable depth. The quality was inferior. Of the seams found, two, neither of them exceeding 2 feet in thickness, were detected close to the left bank of the river, opposite the village of Lingálá. The quality of the coal is rather inferior, and both seams thin out and disappear within a few yards; moreover, as the dip of the rocks at Lingálá is towards the river bed, or south-west, and the outcrop exactly parallel with the bank, it is clear that the beds, even if of good quality, could not be easily worked at this spot, as the whole of them within any reasonable depth must be beneath the bed of the river.

The third seam found crops out in the middle of the river bed; it is about 5 feet thick, and the quality appears better than in the other seams. The reef of sandstone resting on this coal can be fairly traced at intervals for some distance, and after running along the river for about a mile, it turns in towards the right or south-west bank. Here its course becomes obscure. Borings were put down by Mr. Vanstavern near the spot where the coal would probably crop out on the bank, but without success. Another thin seam, only 2 feet thick, has also been detected by Mr. Vanstavern on the right bank of the river. This, like the two first met with, thins out within a few yards in one direction.

I reached Dúmagúdem on the 25th December 1870, and learned from Colonel Haig that besides the coal at Lingálá near the mouth of the Tál, some had been reported farther down the river at a village named Madavháram below Bhadráchalam. This place is below the first barrier on the Godávarí, and is consequently at all times in free communication by water with the coast, whilst Lingálá is above the first barrier, and although communication is now possible during the greater part of the year, it is not easy for laden boats except for a few months. At the spot where coal was said to have been found, I could detect nothing except some shaly dark coloured sandstone, but the rocks around were unmistakeably Damúdás and there was every reason to hope for success in the search.

An examination of the ground showed that the Damúdá rocks extend for a short distance on both banks of the river, but that sections are very few and imperfect. On the left bank which belongs to the Upper Godávarí* districts, there are scarcely any rocks visible except at the hills near Daorpali, and these are probably of a higher group, nearly the whole surface elsewhere being covered with alluvium. The beds appear to extend about six miles along the river from Gogubáká to Nándigúr, but not more than from a mile to a mile and a half from the bank. On the right (south) bank of the river they extend about five miles from Paláram to the bend below Madaváram, stretching for a mile and a half to two miles inland. Above Paláram there is a break occupied by metamorphic rocks for a mile and a half; above this, again, at Pundigúl the Damúdás re-appear and occur for about one and a half miles to a little above Amraváram, then they are covered apparently by the Kámthís, but the two groups here resemble each other so much in mineral character that their limits are difficult to define, especially as nearly the whole surface of the country is thickly covered with alluvial deposit. The Damúdás near Amraváram cannot be traced more than about a mile and a half from the river's banks, beyond this limit they are entirely overlapped by the Kámthís.

Along the right (or south) bank of the Godávarí a tolerable section of the Damúdás is exposed, consisting of conglomerate, sandstone, shale and clay, but no coal. There are, however, many breaks in the section, and it is evident that an examination of these by boring would prove conclusively the presence or absence of any bed of coal extending over the whole field. Local beds, of course, might be found elsewhere, but their value must be comparatively small. It is also manifest that a thorough exploration can only be made south of the river, as to the north the beds are so much concealed that, except in a few spots, all borings must be put down at haphazard.

The general dip seen in the river's bank near Madaváram is to the westward, the rocks at the village being inclined at a high angle and much broken and disturbed; a short distance to the east down the river there is an anticlinal, at the spot where a small stream enters the river. From this point eastwards to the bend of the river, a distance of less than a quarter of a mile, the rocks either have a low dip to the east or are horizontal, and the prevalence of conglomerate shows them to be in all probability near the base or limit of the formation.

It is evident that the anticlinal exposes the lowest rocks to be seen on the river bank, and that a boring at this spot must penetrate beds lower in the series than any exposed elsewhere. On the arrival of the boring tools, I arranged with Mr. Vanstavern for a borehole to be begun at this spot. This was commenced on January 17th and carried on until April 12th, up to which time 192 feet had been penetrated; the borehole was then stopped in

* I do not know who bestowed this name on the districts, but it is an absurd mismomer. The Upper Godávarí can only be that portion of the river's course above its junction with the Pranhitá, if not higher still, where it traverses the Bombay Presidency. Sironchá at the upper extremity of these "Upper Godávarí districts" is 210 miles as the crow flies from the mouth of the river and 400 miles from its source!

consequence of the tools being required to prove the coal discovered on the opposite side of the river. The section passed through was—

	Ft.	In.
1.—Brown sandstone	24	6
2.—Shale and clay of various colours, mostly dark-grey	21	1
3. Coal and shale mixed	0	6
3. Dark-grey shale	0	7
3. Ditto ditto with fragments of coal	0	8
3. Ditto ditto	18	9
4.—White sandstone, conglomeratic in places, with thin beds of shale towards the base	53	9
5.—Shale and clay with a little sandstone	37	2
6. Coal	0	8
6. Black shale and coal	1	4
7.—Dark-grey shale with a few fragments of coal in two places	26	1
8.—White sandstone	8	4
	193	5

I next arranged for a series of fourteen borings to explore the portions of the section not exposed in the river banks to the west of Madaváram between that village and Damarcherla. These varied in depth from 6 to 200 feet, according to the extent of the breaks in the section, and the plan proposed was that all the smaller boreholes not exceeding 35 feet in depth, nine in number, should be made by jumpers with extra lengths of light rods to screw on. The remaining five boreholes alone would require the use of the heavier boring rods. In the ground opposite Madaváram no boreholes were put, because the breaks in the section are trifling, and the disturbance so great that there is reason to believe that a repetition of beds takes place.

To the west of Damarcherla one or two additional boreholes might have been required, but a little beyond the village the beds turn up, dipping east, and then roll over again, and just beyond the small anticlinal, very unpromising conglomerates, perhaps belonging to a higher group, come in, in which there is no break of section which could conceal a coal seam. Two or three small jumper holes were put down to the east of Madaváram.

Of the holes proposed six were carried out, *viz.*, four jumper holes and two boreholes, when peremptory orders were received from the Government of India to discontinue all boring operations in the Nizam's dominions. It is doubtful whether the boreholes in the bed of the river were in the Nizam's dominions, but pending a reference to the Government of the Central Provinces, one set of boring tools was moved across the river into British territory in order to test some ground near the boundary of the field, and close to the base of the measures, on a horizon which did not appear to have been proved by the borings on the opposite bank.

It should be stated that the borings, so far as they had been carried out on the right bank, had shown the existence of sandstones and shales similar in every respect to those seen in the bank of the river, except that in two or three instances small fragments of coal, proving the existence of very thin seams, probably not exceeding two or three inches in thickness, had been brought up by the borer. These little seams, although absolutely worthless in themselves, are of importance, as indicating that the mineral does occur in the beds, and that hopes may be entertained of larger seams being found.

The place selected for a boring on the north or British bank of the Godávarí was on the right or west bank of a stream called the Ganár, rather less than half a mile from the Godávarí, and about the same distance east of the village of Tátpali, at a spot where some brown sandstone, dipping to the south, is seen on the bank of the watercourse. A little more sandstone of the same kind is seen up the stream to the north, and then metamorphics crop out, the latter appearing about 500 yards north of the spot selected for boring. For some distance east and west all is alluvium. It was hoped that a borehole at the spot selected would afford a section of the lowest Damúdá beds; lower than any passed through in the boring east of Madaváram. The borehole was commenced on the 12th April, and the section traversed was—

			Ft.	In.
(No. 1).		Soil and gravel	8	6
		*1.—Brown and yellow sandstone	25	6
	2.	Shale, pale above, darker below	7	0
		Coal	3	0
		Do. mixed with shale	1	0
		Dark carbonaceous shale	5	0
		Coal	3	0
		Dark shale with 2 inches coal	6	0
		3.—White sandstone	27	0
			86	0

The higher 3 feet of coal appears to be of better quality than the lower; an analysis of the small fragments washed from the samples brought up from the borehole gave the following (average of three samples from three different levels)—

Volatile	37·7
Carbon	42·7
Ash	19·6
	100·0

The volatile portion comprised 10·8 per cent. of water. This is by no means a good result, but still some use could be made of such coal, and it should be remembered that analyses of such samples as are obtained from borings are only approximations, although they are usually not far from the true composition.

When I heard of the discovery of coal I was about forty miles from the spot. I marched to it at once, but before I reached it, Mr. Heppel, who was carrying on the borings, had commenced a second borehole on some sandstone in the bed of the Ganár stream below No. 1 borehole at a distance from the first of 125 yards south-east by east. This (No. 2) gave the following remarkable section:—

			Ft.	In.
(No. 2).		1.—Yellow and brown sandstone	28	0
	2.	Shale, partly dark-grey, partly buff	1	6
		Coal	2	0
		Shale	2	2
		Coal	0	6
		Shale	0	6
		Coal	1	4
		Shale	1	4
		Coal	1	0
		Shale	1	2
		Coal	1	8
		Shale	1	2
		Coal	1	
		Shale	0	10
		Coal	1	0
		Shale	2	8
		Coal (shaly)	1	9
		Shale	1	4
		Coal	0	8
		Black shale	5	0
		3.—White sandstone	3	2
			60	8

* The numbers 1, 2, 3, before the several beds in the sections indicate those which are supposed to be representative of the same part of the series in each.

Altogether the combined bed of shale and coal measures 29 feet 6 inches, of which 11 feet 8 inches is coal, but the bands of coal and shale are intermixed in a way which would much increase the cost of working the seam. The astonishing change, however, in so short a distance as 125 yards from a bed 25 feet thick containing 7 feet of coal in two well defined seams exceeds anything usual even in India, amongst the very variable seams sometimes met with in the Barákár group, and this amount of change within so short a distance rendered it doubtful whether the seam could be traced to any distance.

It was now desirable, 1st, to ascertain the extent of the seam, and 2nd, its quality. For the extent two boreholes were put down, one to the east, the other to the west, at a distance of about one-third of a mile from No. 1, on the supposed strike of the coal seam. All the ground east and west for a considerable distance being completely covered by alluvium, the true strike could only be inferred from the line of outcrop of the metamorphic rocks to the northward. To the east the borehole (No. 4) was a complete failure. It was put down in an open plain north of the village of Ganára. It passed through 34 feet of earth and 18 feet of quicksand, in which no further progress could be made, as the sand filled the tube faster than it could be removed by the "pump" or mineral lifter. A second borehole 200 yards farther south (No. 5) was equally unsuccessful. After passing through 22 feet of soil and 24 feet of quicksand it also had to be abandoned. There was not time for more attempts in this direction.

The boring to the west (No. 3) was on higher ground, just south of the village of Tátpali. It gave—

			Ft.	In.
(No. 3).		Soil and gravel	3	7
	1 ?	Sandstone, yellow, brown, and red	29	9
	2 ?	Pale coloured shale	10	0
		Red and yellow sandstone with some shale	7	0
		Shale, pale and dark	13	0
	3 ?	White sandstone with a little shale and brown sandstone ...	24	8
			88	0

In my absence this borehole was stopped by Mr. Heppel, and another (No. 6) started 250 yards to the south-east. This was on somewhat lower ground, and as the beds dip south at a low angle the section is probably that of the same beds—

			Ft.	In.
(No. 6).		Soil	11	0
	1 ?	Brown sandstone	13	10
	2 ?	Buff shale	6	0
		Red sandstone	2	0
		Dark shale	6	0
	3 ?	White sandstone with darker bands	46	0
			84	10

These sections I am strongly inclined to believe are in the same beds as Nos. 1 and 2. We have the same general succession, brown and yellow sandstone above, then a thick bed of shale, and then white sandstone. I have recommended that one of the boreholes should be carried out to a greater depth on the possibility of these beds belonging to a higher horizon, but I cannot think this at all probable. The evidence afforded by these boreholes appears to indicate that the coal thins out and disappears to the westward within a short distance.

Meantime a locality for a small pit had been selected up the Ganár stream 350 yards north-east of No. 1 borehole, at a spot where some yellow sandstone, just like that immediately over the coal, crops out in the bank of the nala, in the expectation that this would be close to the outcrop of the coal, and that a sinking of a few feet would produce abundance of coal to enable the quality to be fairly tested. A jumper hole, subsequently deepened by boring (No. 7), was put down in order to ascertain the presence of the coal. This gave—

			Ft.	In.
(No. 7).	1.—	Yellow sandstone	29	6
	2.	Buff shale	24	0
		Dark shale	6	0
		Coal	1	3
		Dark shale	26	3
			87	0

showing that the beds are nearly flat, and that a great increase of thickness in the shale has been accompanied by a diminution in the coal. A pit was therefore commenced close to No. 2, but when it was only 13 feet deep, the quantity of water met with retarded progress so much that it was considered advisable to commence another on the high ground 30 yards west of No. 1, as, although it would be a little deeper, it would not be equally liable to flooding, and might be used for the extraction of coal. A borehole has shown that the section is the same as at No. 1. This pit is now in progress.

Meantime one more boring (No. 8) was made only 200 yards west-by-north from No. 1. The section was—

			Ft.	In.
(No. 8).		Soil and gravel	10	5
	1.—	Coarse brown sandstone	4	0
	2.	Light coloured and buff shale	9	0
		Red sandstone	3	0
		Light blue shale	2	9
		Red sandy clay	14	3
		Variegated clay	13	0
		Dark shale	21	7
			78	0

This boring was in progress when I had to leave at the end of May, and I have not yet received accounts of its completion. The enormous thickness of shale recalls the section in No. 7, and both sections may possibly be below the white sandstone which underlies the coal. But it is more probable that the shale represents the shale and coal found in the two first boreholes.

Lastly, as the absence of coal had been proved to the north-east and west, and no borings had been found practicable to the east, while the ground to the south appeared equally unfavorable for boring, except at a place on the bed in the Godávarí where operations might at any moment, at the season now reached (June), have been stopped by a rise in the river, a borehole was recommended 500 yards south of No. 8 and south-south-west of No. 1. This (No. 9) has given the following section, sent to me by Mr. Vanstavern since my arrival in Calcutta—

			Ft.	In.
(No. 9).		Soil &c.	39	0
	1.—	Brown sandstone and conglomerate	23	0
	2.	Dark shale	3	0
		Ironstone	2	6
		Shale	2	0
		Coal	1	6
		Shale	2	0
			73	0

		Ft.	In.
		73	0
2.	*Coal*	2	1
	Shale, carbonaceous	2	0
	Coal	1	6
	Shale, carbonaceous	1	6
	Coal	1	6
	Shale, carbonaceous	1	0
	Coal	1	0
	Shale, carbonaceous	2	0
	Coal	1	0
	Shale, carbonaceous	1	0
	Coal	2	0
	Shale	23	0
		112	7

The section is remarkably like that at No. 2. It decidedly strengthens the evidence in favor of all the boreholes having passed through the continuation of the same beds, for we have in this case a great thickness of shale as in Nos. 7 and 8, with the coal as in No. 2. The total thickness of coal as yet proved in this last borehole is 10 feet 7 inches.

To sum up the evidence: the presence of coal has been proved over a small area which contains probably 25,000 tons, or rather more, of which quantity it is as well not to assume that more than one-half can be profitably extracted, owing to the great admixture of shale. It is probable that the seam may be traced for some distance to the south, because the amount of coal, so far as is known, increases in that direction, but it is hardly likely that a seam which thins out and disappears within so short a distance as 200 yards can be depended upon for any long distance. The quality has not yet been accurately ascertained. If on cutting into the coal it is found to burn fairly, a considerable quantity may be extracted, far more than sufficient to well repay the expenditure incurred in boring, but, except in the improbable case of the coal continuing for a distance to the south and east, no permanent supply can be depended upon from this locality. The great admixture of shale and the variation in the seam will render it necessary to mine a large quantity of useless rock, and this will increase the cost of the coal, but in a country where no other supply exists, this alone should not prevent the coal being worked.

The locality is most favorable. The river is within half a mile when full, and about a mile during the dry season, and so soon as the coast canals are completed, it will be in constant water communication with Madras.

In conclusion, I would recommend that the remainder of this small tract of coal-bearing beds be thoroughly explored, as, even if no extensive seam of coal be found, a considerable quantity of useful fuel might be discovered, which would be available on an emergency. North of the river a borehole should be put down below the high bank at Rajgúmpa, at a spot where conglomerate is seen in the river bed, in order to test if the coal continues so far to the south-east. A boring might also be made where sandstone occurs in the stream north-east of Gaoriopeta, and another south of the large tank near Egerpeta, west of Tátpali, and one of the boreholes already sunk, for preference No. 1, should be continued until the metamorphics or Tálchírs are reached. There is little chance of good from any further exploration on the north bank. On the south or right side of the river, the series of borings planned west of Madavâram should be carried out. The small breaks in the section near Amravâram might be explored in the same manner, and especially a spot above the mouth of the large stream which enters the Godávarí just above the village, as small fragments of shale and coal are hereabouts scattered along the edge of the river, and may indicate a coal seam below the sandstone exposed at a place where there are some bushes beneath the bank.

If all endeavours to find a permanent coal supply in this locality fail, an eventuality for which we must be prepared, the next chance is near Lingálá. Here I consider further exploration in British territory as almost hopeless, the Tálchírs must crop out everywhere below the mouth of the Tál close to the river bank, so that the Damúdás are confined, or nearly so, to the bed of the river and the country on the opposite side. Above the mouth of the Tál for some distance it is simply impossible to say what exists, for the whole country is covered with thick alluvium as far as Cherla, where the only rocks that are known to occur appear to me undoubtedly Kámthís, and all the Damúdás and Tálchírs are overlapped. The only plan by which any good can be done is an exploration of all the breaks in the section exposed above the top of the Tálchírs at Sangáram on the right bank of the river in the same manner as I have recommended near Madavâram. The dip varies from 10° to about 20°, and the depth to which the boring in each case must be sunk will be found by multiplying the length of the break by the tangent of the angle of dip.

I am under great obligation to Mr. Vanstavern for the very thorough manner in which he has aided me, and for his readiness to carry out every suggestion I made. Mr. Heppel's services in charge of the boreholes were invaluable; it is mainly due to his thorough knowledge of boring and to his hard work, in an intensely hot season and despite many difficulties, that so much has been accomplished in a short time.

CALCUTTA,
July 6th, 1871.

NOTE ON THE NARBADÁ COAL-BASIN, *by* H. B. MEDLICOTT, A.M., F.G.S., *Deputy Superintendent, Geological Survey of India.*

From the point of view of uncertainty and of expectancy the Narbadá coal-fields are at present the most important in India. They are the nearest known source of coal for the great region of North-Western India, where so many miles of railway are either open, under construction, or projected. Even as communications now stand, with the circuit through Jabalpúr and Allahabad, these fields are much nearer than those of Bengal to the Panjáb. When the rails are laid through Malwa and Gwalior the length of carriage will be greatly reduced. Yet less is known regarding the resources of the Narbadá area than of almost any other. The Wardá fields have been comparatively recently brought to notice; but their value and extent have been so well established by systematic boring experiments that the working of them is now only a question of time and convenience. Until similar trials are made in the Narbadá fields the prospect of a supply of coal there must remain uncertain, the naturally exposed sections of the rocks being so very obscure. There is an immense area beneath which it is possible, or even probable, that coal exists; but its presence and the depth at which it must be sought are still unknown. In connection with this there is an interesting question of stratigraphy to be discussed, and which would be out of place in this brief notice of practical objects; the more so that I believe no amount of discussion upon surface observations could in this case finally settle the point or remove the necessity for actual exploration. The occurrence of a fine outcrop of coal in a convenient position at the northern edge of the basin, and the formation of an efficient mining establishment to work it, have, no doubt, contributed with other causes, such as the want of proper maps, to keep in temporary abeyance the further exploration of the field; but it is evident that this should no longer be deferred. My brief report of last year (Records, Geological Survey, Vol. III, Pt. 3,) showed how much need there was for information regarding even the seams on the Sitárivá (at Mohpáni); how limited their known extension; how broken, crushed, and even locally destroyed they are within those small limits; how urgent it was

Lithographed in Colors at the Surveyor General's Office, Calcutta. July 1871.

to ascertain their extension beneath the younger rocks to the south. Although little information has been gained within the last twelve months, and that little not very encouraging, the importance of the case makes it worth noting. The following notes, in continuation of my last year's report, refer only to the northern side of the coal region: every endeavour should be made to find the coal there before attempting to work the distant outcrops of the Upper Tawa valley, on the south side of the basin. The localities to be mentioned in this paper may be followed upon the small map attached to the report of last year, or upon the large sketch map of 1859.

During part of the past season I examined a number of sections along the northern side of the area of sedimentary rocks from end to end, but without discovering an outcrop of the coal-measure rocks (the Barákar group). This direct evidence failing, the fact that has most encouraged hope of the proximity of coal has been the occurrence in several places of Tálchír rocks, which so constantly underlie the coal-measures. The outcrop in the glen south of Futtehpúr was mentioned in last year's report. A much larger spread of the same rock is seen at the edge of the plains south of Dhábká, eight miles east-south-east of Sohágpúr: again, to east of the Sitárivá, half way between Chungaon and Hatnápúr, close on the west of Nibhora village. But even this evidence is open to doubt: in all cases the rock in question is indeed the lowest seen, and is identical with the well known Tálchír boulder clay; but except for the boulders (which are not of large size) an identical clay is common in the adjoining Máhádévá rocks, alternating with the more common mottled red clays. Thus, the identification of this boulder bed as Tálchír rests largely on the assumption that there is no such bed in the Máhádévás; it is certainly very different from the ordinary conglomerates of this series. It is moreover noteworthy that in the undoubted Tálchírs of the Sitárivá section *sandy* rocks prevail: even the boulder-bed is principally a sandstone, the clay being subordinate. I am, however, decidedly of opinion that the rock in the localities noticed belongs to the Tálchírs. The presumption thus gained in favor of the proximity of the coal-measures along this edge of the field is, no doubt, an uncertain one; but it is something; the Barákur and Tálchír groups being about the two most constant companions of all the groups of the great plant-bearing series. It will probably be advisable at some early date to make one or more deep borings through the Máhádévá rocks at some little distance from the edge of the basin; but, as was urged last year, it would be unwise to attempt this until it be seen what can be learned from the exploration of the Sitárivá field as to the conditions of the formations in passing southwards.

Very little has been added during the past year to our knowledge of the seams in the Sitárivá (Mohpáni) field. What explorations have been made only bring into clearer view the greatly disturbed condition of rocks within the area exposed, and the corresponding deterioration of the coal. In the pits on the vertical seams at the north edge of the field the coal has become greatly squeezed-out at a depth of 100 feet, and along the strike westwards, being at the same time reduced to an useless paste. Some shallow excavations on the outcrops in the ravine to the north of the Narbadá Company's mine show the coal to be tremendously crushed and mixed with the associated rock; two strong trap-dykes here passing within a hundred yards of each other right through the measures. The trial boring at Pukuhi was carried to a depth of 110 feet. The result was inconclusive and, in a measure, unexpected. The sandstone, which from its position and general appearance it was thought might be the top-rock of the coal-measures, proved to be only a band in the Máhádévás; the bore having gone through some 60 feet of the typical red clay beneath it. Below this, however, the bore passed through dark-brown and dark-grey, slightly carbonaceous, clay. Such a rock would be very unusual in the Máhádévás in this position; and would, on the contrary, fairly represent the top of the coal-measures in the northern section on the Sitárivá; the two being, moreover, on the same general strike. Regarding the southern extension of the seams, where, it may be hoped, they become steadier and farther from trap, no result has as yet been attained. The small trial-shaft and boring close to Benár on the north-west not having proved coal within 50 feet, Mr. Taylor shifted his operations to a point south-east of the village, and well in on the Máhádévá rocks where he is now boldly sinking a shaft. He could not, within his limits, have chosen a better position for making a thorough trial of the ground. According to the nearest dip seen (25°), and supposing no intervening fault, the shaft may have to be sunk 235 feet before striking the measures; but there is hope that the dip flattens, so as to lessen the depth. The shaft is now 98 feet deep, 92 feet of which were through an unbroken mass of mottled red clay, locally silicified and very hard, but all requiring to be cased up. The bottom 6 feet are in a firm, clear gray, sandstone-conglomerate. The plane of junction, which (Mr. Taylor informs me) seemed regular, thus affording a fair observation of the dip, sloped at 18° to the south-south-east. The prospects are so far improving. The spirited enterprize of Mr. Jones, the present proprietor, deserves every success.

In my small map of last year I marked some Tálchír rocks, with a query, on the south of Puwaria village. A re-examination of that obscure section, later in the season, when the ground is less concealed, has convinced me that the rocks are Máhádévá; thus making the suppression of the older rocks to the westward of the Sitárivá much more rapid than was at first apparent. But there is no deciding as to the manner of this suppression; it may be altogether due to faulting or to folding of the strata. The alternative supposition to that of disturbance to account for this so sudden disappearance of the coal-measures would be that there is strong denudation-unconformity between the two rock-series. There are some puzzling sections about the mines seeming to corroborate this view of the case; still it is hard to get over the fact first adduced against it—that in the best exposed sections the succession of the rocks seems regular. And there certainly can be no objection now to the supposition of disturbance. The unpromising nature of the ground in this position, at the edge of the basin, is further displayed in this section at Puwaria by the discovery of four strong trap-dykes, or at least outcrops (the section is so flat one cannot positively say how the trap occurs), in a length of about three quarters of a mile.

Several new outcrops of the lignite-coal in the Upper Máhádévá rocks have been examined during the past field season in the hills east of the Sitárivá. They all bear out the opinion already given on the subject.

There remains to notice the coal near Lokartálai at the extreme west end of the basin, so far as exposed at the surface; the whole sedimentary series there passing beneath the trap. The coal-band here seems different to any yet noticed. It occurs (see small map annexed) at some distance from the boundary of the metamorphic rocks, being exposed in a trench cut by the Moran across a flat anticlinal fold of the strata. The upper rock is a strong pebbly Máhádévá sandstone, but on what exact horizon has not been determined, immediately beneath which come the earthy coal-bearing beds. There is the usual appearance of complete conformity; the upper rocks dipping at the same angles as the lower; and the same beds of shale being identifiable on both sides of the anticlinal; a thick bed of nodular and shaly, micaceous and carbonaceous clay is recognizable at a few feet below the sandstone on either side. There are altogether about 80 feet of the lower rocks: 40 to 50 feet at top are earthy, some of the layers of shale containing strings of bright coal. These are best exposed in the southerly elbow formed by the river. They rest upon a thick mass of fine sandstones, between which and a similar mass below occurs the principal seam. It is about 4 feet thick. What coal there is in it is very bright; but shale predominates in the mass, and there is a great deal of pyrites. Some explorer had last year cut a short drift into the seam and evidently abandoned it as worthless. This seam is about the lowest bed exposed on the back of the anticlinal. I do not think that this band of coal-bearing rocks belongs to the Barákar group. I rather think it belongs to those younger beds of the Damúdá series so largely exposed along the south base of the Pachmari range, and in which as yet no coal-outcrops of any promise have been found. Or, it may possibly belong to the Máhádévá series. I was not fortunate enough to find any fossils to determine this point; and owing to the isolated position it will be a very tedious matter, if even possible, to work out the question stratigraphically.

CAMP, }
May 1871. }

SKETCH OF THE GEOLOGY OF THE CENTRAL PROVINCES, *by* T. OLDHAM, F. R. S., *Supdt., Geological Survey of India.*

[In connection with the valuable series of Gazetteers which are now in course of publication under the authority of Government, the Geological Survey have from time to time afforded information to the officers charged with their compilation. This has frequently been on isolated points, but we have also been urged to give general and sketchy outlines of the geology of the various provinces viewed more as a whole. Such sketches are necessarily brief, being very limited in the space intended for them, but they may be useful to others as giving a more general outline than separate reports could do. It is, therefore, in contemplation to reprint these in the present series of records. Of those which have been already furnished, that of the Central Provinces has appeared soonest. It is now given here. It was written entirely without a single map or record for reference, and very hurriedly under great pressure for time. Others of Orissa, North-Western Provinces, Bombay, &c., will follow.] T. O.

Diversity of the geological character of the country.

To give a general description of the geological structure of the Central Provinces in any detail would involve the necessity of entering upon a discussion of the geology of India at large, as these provinces contain representatives of almost all the formations known to occur within Indian limits, although frequently these are much better seen in other districts, and ought, therefore, more correctly to be described in connection with the locality where the most typical sections occur. In the very brief notice which follows I am therefore compelled to presuppose a certain amount of acquaintance with Indian rocks, and the classification of them. It is only necessary to state that the few descriptions which follow have been drawn up under great pressure as to time, and while actively engaged in field work of an important and intricate nature, and away from all maps and records.

General correspondence of geological and physical areas.

The Central Provinces, divided into nineteen districts, naturally group themselves into separate areas, corresponding to well-marked physical features. These again have in a similar way a general agreement with the geological structure. To the north the districts of Ságar and Damoh are altogether on the Vindhyan plateau, and a large part of their surface is formed of the deposits to which the name *Vindhyan* has been given. These are, however, concealed over considerable areas by the overflowing volcanic rocks of the great Deccan trap area. Physically also these districts (as is all the Vindhyan plateau) are connected with the country to the north, all the drainage of the area being into the Ganges valley. Immediately to the south of the Vindhyan escarpment, along the marked depression of the Narbadá valley, lie the four districts of Jabalpúr, Narsinghpúr, Hoshangábád, and

Nimár (taking them in order from east to west), which are in great part on alluvial and tertiary deposits, with a narrow belt of older rocks along the southern side of the valley. South of the Narbadá valley rise the extensive highlands constituting the Sátpurá range, or its continuation, which are in great part formed of the Deccan traps resting upon crystalline rocks, or upon sandstone and other rocks of later date. Of this region Mandla occupies the extreme eastern end, bounded by the steep escarpment of the trappean plateau, near to the edge of which the Narbadá river has its source at Amarkantak. Along this same range to the west lie parts of Bálághát, Seoní, Chhindwárá, and Betúl. South and south-east of the Sátpurá ranges lie the remaining districts. Biláspúr, Ráípúr, and Sambalpúr lie in the great drainage basin of the Mahánadí. The two former occupy the low plain country of Chhattísgarh, formed principally on rocks believed to belong to the *Vindhyan* series, with a part of their area covered by coal-bearing rocks. Sambalpúr is in a rugged jungly country composed of crystalline and metamorphic rocks. The great drainage basin of the Godávarí, on the other hand, includes Nágpúr, Bhandára, Wardhá, Chándá and Sironchá. These districts have no very considerable elevation. The two first are principally on gneissose rocks, with much trap in Nágpúr: Wardhá is almost entirely on trap-rocks; Chándá and Sironchá have a very varied structure, including more or less of all the formations that have been named.

Geological groups.
Crystalline and metamorphic rocks.

These formations may be noticed in ascending order. The crystalline and metamorphic rocks have not as yet been described in any great detail. Gneiss of different varieties, often highly granitoid, predominates. The frequency with which these rocks appear shows how closely to the surface they form the substratum of the whole area. They are found at intervals all round the irregular boundary or border of the trappean rocks, rising in several places nearly to the full height of the plateau. The principal areas occupied by them are in Nágpúr and Bhandára and in Betúl. Also in Sambalpúr a very large area is formed of these rocks; but this is naturally connected with, and belongs to the great Gneissic area of Bengal. In obscure relation to the gneiss there occasionally appear sub-metamorphic rocks, schists, slates, and quartzites. These may be seen at many points along the borders of the Narbadá valley, from the north-east of Jabalpúr into Nimár.

Sub-metamorphic rocks.

Vindhyan series.

The great *Vindhyan* series of strata which form so prominent and important a feature in the geology of Hindustán are the next deposits in succession of age found in the Central Provinces. There is, however, a wide and complete separation of these from the gneissose rocks. They are universally unconformable to the latter, and they exhibit little or no mineral alteration, and only very locally any marked mechanical disturbance. The range or escarpment, from which the name of the series has been adopted, forms the northern boundary of the Narbadá valley, and the districts of Ságar and Damoh are occupied by the upper member of the series—the *Bhánrer* and *Rewá* groups. Each of these groups consists of a strong band of sandstone resting upon shales with subordinate limestone—an arrangement which, coupled with the nearly horizontal position of the beds, has, through the operation of denudation, produced the peculiar surface features of the country, namely, local plateaus bounded by precipitous scarps, overlooking broadly undulating valley-plains—features even better seen in the Rewá country. The Bijerághogarh *pargana* in the north-east corner of the Jabalpúr district lies within the geological region of the Son valley, where the *Lower Vindhyan* rocks are so well exposed: they consist of less uniform alternations of shales, sandstones, and banded limestones, with some peculiar compact silicious (cherty and jaspery) layers, very homogeneous and regularly bedded. Along the entire southern margin of the *Vindhyan* area these rocks both '*Upper*' and '*Lower*' are much crushed and contorted, but they are only locally (in the south-west) penetrated by igneous rocks, probably of the same period as those of the great basaltic area. The extensive plains of Bilåspúr and Ráípúr are formed on rocks very similar in composition, arrangement, and external relations to those of the ***Lower Vindhyan*** formation as seen to the north, and these extend from here along the upper courses of the Mahånadí into very close proximity, if not actual continuity, with the similar deposits in the Chåndå and Sironchá districts, and beyond the limits of the Central Provinces to the south, extend at intervals into the Madras Presidency, where they cover an immense area in the Kaddapå and Karnúl districts. Our knowledge of these detached areas is not as yet sufficient to justify an assertion that they were once continuous, although the striking identity in lithological character of the several deposits lends strong support to this view. Throughout all these widely-extended deposits there is constant physical evidence of their having been accumulated in comparatively shallow water, and so far under physical conditions favourable to life. The sandstones are false-bedded and beautifully rippled on their surfaces, each successive bed, often for hundreds of feet in thickness, showing its own ripple-marked surface. Nor is there anything in their mineralised condition to suggest the chance of subsequent obliteration of organic remains, had they ever been imbedded or become fossilised. Yet no success has hitherto rewarded our most careful searchings for such traces of early existences.

Coal-bearing rocks.

Passing upwards in the historical succession of rocks, we find in India a wide gap in the geological record between the *Vindhyan* rocks, just alluded to and the next succeeding series of deposits, in which are included the coal-bearing rocks. The whole face of the country wherever these occur must have been entirely remodelled by long-continued denudation and other causes before the commencement of the deposit of this great plant-bearing series of beds. This series has attracted much attention, both from its economic importance, and from the fact that it is in all its groups more or less fossiliferous. And the proper sub-division of it as represented at distant localities has been the subject of much study. Nor has the detailed examination of the country yet been sufficiently extended to admit of a final decision of this question.

Sub-divisions.

Three great groups have, however, been thoroughly established—the ***Tálchír***, the ***Damúdá***, and the ***Panchet*** rocks, and representatives of these three great groups have been found wherever the general series occurs. It is solely as to the exact limits of each that any question still exists, which can only be answered after more detailed examination. This question is, however, of high practical importance, because of the three series which I have mentioned only one is proved to contain workable beds of coal. The ***Tálchír*** rocks below contain no coal, and the ***Panchet*** rocks above are equally without any coals, the whole of the workable beds of coal of this geological epoch being found confined to the ***Damúdá*** rocks.

Sátpurá coal-fields.

The largest area occupied by the rocks of this great series within the Central Provinces lies in the hilly region to the south of Hoshangábád and Narsinghpúr, partly within the boundaries of these districts, but principally belonging to Chhindwárá, and embracing the Pachmarhí or Mahádeo hills. At the base of the series we find the characteristic deposits of the ***Tálchír*** group—greenish silt beds, breaking up into small splintery flakes and sharp fragments, and hence called 'needle shales,' and greenish brown or whitish earthy felspathic sandstones, in either of which pebbles and large boulders are often irregularly scattered. Often these are very numerous and form a distinct bed, to which, from its peculiar constitution, the name of "Boulder" Bed has been given. These rocks, generally speaking, are found at the edges of the field, or weathered out in the deep valleys. The thickness of this group is variable, never very great, and it is locally altogether overlapped. In the Narbadá it covers by far the larger portion of the area. As noticed, no coal has ever been found in the *Tálchír* rocks, and very rarely any of the dark carbonaceous shales which are so frequent an accompaniment of coal, with the exception of a few thin and irregular streaks which invariably mark the transition of these *Tálchír* rocks into the *Damúdá (Barákar)* rocks above. This *Damúdá* series is chiefly made up of thick-bedded, often coarse felspathic sandstones, with subordinate beds of blue and carbonaceous shales and *coal*. In Bengal and towards the east this series is of great thickness, and is easily divisible into several distinct groups. But towards the west and the Central Provinces the series is of much diminished thickness, and the sub-divisions so well marked in Bengal are not recognisable. The beds of coal in the same way are much fewer and less important. These variations appear to have only a local development when viewed in detail, while on a general comparison the facts would seem to be expressed by saying that the *Panchet* series, which immediately succeeds the coal rocks, assumes towards the west a much greater thickness and importance than in the east, while the *Damúdá* series has been much less developed. In the Narbadá valley the latter series is represented by one group of beds only, which belong to the lowermost group recognised in Bengal (the *Barákar*), of no great thickness, and covered by an immense series of sandstones of varying age. No trace of any one of the sub-divisions of this great plant-bearing series—*Tálchír*, *Damúdá*, or *Panchets*—has been found to the west of about the parallel of Hoshangábád (Lokhartalai). The *Damúdá* rocks cover a wide spread of country round the bases of the noble Pachmarhí hills, and extend thence to Umréth and Barkoí, about sixteen miles from Chhindwárá. They rest in parts immediately on the gneissose rocks, and are frequently succeeded directly by the great trappean flows.

Western limit.

In Biláspúr (Chattísgarh) a large area of widely undulating country along the Hasdú—an affluent of the Mahánadí—is also formed of these rocks, and coal has long been known to exist there in some quantity. The district has not been examined as yet, and no trustworthy information exists as to the quantity or quality of this coal.*

Biláspúr coal-fields.

In the Chánda district again, and in Berár adjoining, similar *Barákar* rocks are found resting upon the characteristic *Tálchír* beds, and occupying a very small area in the large field of sandstones which there occur. At least one thick group of beds with coal is known in which the coal itself exhibits the same characters which distinguish the beds in the *Barákar* series elsewhere—that is, there is rapid and considerable variation in the thickness and quantity of the coal. Beds of great thickness have, however, been met with, and there is a very large supply therefore of useful fuel.

Wardhá River coal-fields.

Similar rocks extend down the valley of the Godávarí and the Pranhítá for a long distance, occurring in detached localities separated by wide ridges of the older formations. Near the mouth of the Tál river about fourteen miles above Dúmagúdem, both *Tálchír* and *Damúdá* rocks occur, the latter containing coal, which form the bed of the river Godávarí for some distance, and have probably a considerable extension; and coal is also known to occur about thirty-four miles to the south of the same town, visible on the banks of the river.

Godávarí and Pranhítá.

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* See later information in Records Geological Survey of India, 1870, p. 71, also p. 54.

We are not as yet able to speak so certainly of the limits and relations of the beds which occur immediately above these coal-bearing rocks, so far at least as parts of the country under notice are concerned. In the Narbadá valley coarse conglomeratic sandstones with ferruginous bands, which are believed to be the representatives of the *Panchet* rocks of Bengal, come in immediate succession on the *Barákar* beds (Mohpání, &c.). And similar rocks occur in the same relation in the wide flats of Chhattísgarh, and probably at the intermediate locality of the Chhindwárá fields.

Kámthí sub-group.

But passing into the drainage basin of the Godávarí, a series of rocks of peculiar lithological character and locally abounding in fossil plants, is met with, no exact representatives of which are as yet known elsewhere. In their general mineral aspects they come very near to the ordinary *Panchet* rocks of Bengal, and they appear to pass upwards into undoubted representatives of these, but the prevailing form of fern of which they contain the fossilised fronds, is one *(Glossopteris browniana)* which is scarcely known to extend up to the *Panchet* horizon. These beds would therefore seem to indicate either a commencement in the basin of the Godávarí of the deposition of rocks having the peculiar mineral character of the *Panchet* beds at a much earlier period than in Bengal into which these ferns continued to exist: or the flora of the Godávarí basin had not been subjected to the same influencing causes, resulting in a marked change in its character, which in Bengal led to the well-defined separation as to fossils of the *Panchet* and upper groups of the *Damúdá* rocks *(Raníganj)*. I am disposed to think that, viewed in a very general way, it gives the truer representation of the facts to consider these local rocks, notwithstanding their contained plants, as belonging rather to the *Panchet* series than to the *Damúdá*. And there is one very important practical reason for this also, inasmuch as no workable coal has yet been found in either of these groups, while it has invariably been seen to occur where rocks of the undoubted *Damúdá* age are developed.

A local name was provisionally given to these rocks by Mr. W. Blanford, who first examined them, and as this has been published (although unintentionally), it may be retained as a useful sub-division. One of the largest areas of these rocks in the Nágpúr country is close to the important military station of Kámthí, and from this circumstance Mr. Blanford spoke of them as the *Kámthí* beds. They consist, lithologically, of hard compact gritty sandstones, fine variegated sandstones, coarse loose-textured sandstone, very fine-grained deep and bright red and buff argillaceous or argillaceo-silicious sandstones, and bands of hard very ferruginous pebbly grits.

These rocks cover an area of about twenty-five miles long from north-west to south-east near Kámthí (Kámthí to Kélod), and at the broadest parts (near Pátansáongí) about eight miles wide. Over a large portion of this area the rocks are concealed by thick alluvial deposits, but they are well seen at Kámthí, Silewárá, Bhokárá, and south and south-east of Pátansáongí, &c. A small area of the much older *Tálchír* rocks is seen north-east of Bhokárá, and a small hill north-east of Pátansáongí. Two other localities where these rocks are seen have been exposed within the area of the trap-rocks, these having been removed by denudation. One—the larger of the two—is close to Behár and Bázárgáon, about fifteen miles from Nágpúr on the road to Amráotí. The rocks here are of the same type, but become more conglomeratic towards the top than is seen near Nágpúr. The other inlier of these rocks is about thirty-six miles north-west of Nágpúr, near the village of Chorkherí. The rocks extend over an area of only about six and a half square miles in all. There is also another very small patch not a mile long near Khútkherí, about one mile south-east of the other.

Passing further southward similar rocks are more widely developed in the Chándá district, and cover a large area, concealing the underlying *Barákar* beds; there the rocks are, as a whole, less fine-grained than in the neighbourhood of Nágpúr, and the tendency to become more conglomeratic in the upper beds of the group is still more markedly exhibited than in the case already noticed. In this field also they appear to be closely connected with, and to pass up into a great thickness of bright red clays with thin-bedded sandstones, which belong undoubtedly to the *Panchet* series—well seen in the Wardhá about Porsá and in the country round, giving additional evidence of the connection of the two groups. These rocks—the *Kámthí* beds—yield in many of their beds admirable building stones, while others of a coarser texture are used as millstones or querns. Quarries exist at Kámthí, Silewárá, Bhokárá, &c., also in the Chándá district, but owing to the comparative poverty and sparseness of the population, they are here less worked than in the Nágpúr country. The white argillaceous band which is used near Chándá town, and which can be traced for miles along the country, is very even in texture, and can be carved into very minute forms of ornaments (a kind of work which is very skilfully done at Chándá), but it is rather soft. The beds, excepting the hard ferruginous pebbly grits, are not, generally speaking, very compact, and the surface of the ground becomes covered with loose sand resulting from their disintegration. The soil on these, except where they are covered by the alluvial deposits, is poor and little cultivated, almost the whole of this tract being covered with jungle.

The fossils found in these *Kámthí* beds have been noticed above. The fine sandstones of Kámthí, Silewárá, &c., have yielded very beautiful and numerous specimens of the large *Glossopteris Browniana*—a fossil-fern common in the coal-bearing rocks of Bengal and also in those of Australia. Similar fronds are found, but more rarely, in the finer beds of the vicinity of Chándá.

We have noticed these so-called *Kámthí* beds a little more in detail than their relative importance in a general sketch would justify, because of their local development, and of the interesting fossils which they contain.

Panchet series.

In ascending order the next important series of rocks is that to which the name of *Panchet* has been given. This, which is a very extensive formation in Bengal and in the country intervening between that and Jabalpúr, is not so largely developed in the Central Provinces. Indeed there is still much doubt as to the true limits and true parallel of many of the rocks which would probably at first be classed under this group. There is another peculiar feature: in the Bengal coal-fields, the so-called *Lower Panchet* group, consisting principally of red clays, with fine-grained, thin-bedded, often calcareous sandstones, both of red and greenish white colours, forms a set of beds of very considerable thickness and wide extent. But on passing to the west this group rapidly disappears and soon seems to be entirely wanting, while the *Upper Panchet* group, consisting chiefly of coarse red conglomerates, &c., with numerous ferruginous bands, becomes more largely developed, and constitutes almost the whole of the series. Still further to the west, however, as in the Chhindwárá fields near Umréth, these red-clays and thin-bedded fine-grained sandstones recur with a considerable development. And similar beds cover a large area on the south of the Chándá coal-field (Porsá and all the country around), and also appear in other minor patches throughout the Chándá field and in Berár. These pass upwards into coarser beds, pebbly and conglomeratic, and it is not an easy task to make out the exact relation of these to the adjoining rocks in a country so very much covered as is the greater part of the Chándá district. Similar rocks are seen again further south (Maledi), and here, as at Mángli to the north of Chándá, have yielded organic remains, which establish with tolerable accuracy their true position in the general European scale of geological formations.

Several forms of *Labyrinthodont* reptiles from the *Lower Panchet* rocks of Bengal remains of the very remarkable genus *Dicynodon*, previously only known from South Africa, and abundance of *Estheriæ* (small bivalved crustaceans) mark the fauna of the time in Eastern India. In the Central Provinces similar *Estheriæ* and a remarkable reptile *(Brachyops laticeps)* have been obtained from Manglí thirty miles north of Chándá, while the red clays of Maledi afford numerous remains of the very curious and interesting *Hyperodapedon*, *Belodon*, and some *Labyrinthodont* fragments also. There is a high probability that the rocks at these different localities are all truly on or about the same geological horizon (a fact which can only be satisfactorily established by detailed and careful observation), and that that horizon represents in Indian geological homotaxis the period of the *Trias* of Europe.

Jabalpúr beds.

In the vicinity of Jabalpúr and stretching down the valley of the Narbadá to the Sher river, and a little beyond, and forming also a narrow outcrop fringing the general line of the trappean boundary to the east and north of Jabalpúr, a distinct group of rocks was recognised by Mr. J. G. Medlicott in 1856-57. This limited group of beds is partially coal-bearing, and from this fact and from certain other obscure relations, it was at first designated under the inappropriate name of *Upper Damúdá*, with which series it was, pending further inquiry, supposed to be connected, while the fossil plants which it imbedded were closely allied to those occurring in the *Jurassic* beds of Rájmahál and Cutch. Subsequent inquiry showed that there was really no ground for supposing any connection of these beds with the true *Damúdá* as parts of one formation, and the name *Jabalpúr* group was substituted for *Upper Damúdá*.

At about 100 miles to the north-east of the Narbadá coal basin the boundary of the plateau of trap-rocks recedes south-eastwards, and the narrow outcrop of these *Jabalpúr* beds expands here into the open ground of South Rewá; there the *Jabalpúr* shales and silt beds were found passing upwards into massive sandstones (at Bandogarh) so generally identical with the rocks of the great Mahádeo hills, that they were at once accepted as their representatives ; while below the *Jabalpúr* shales overlaid strong pebbly sandstones and conglomerates, which again in the southern part of the same area rested upon a coal-bearing group, recognisable at once by its contained fossils and general character as representatives of the *Damúdá* series. The *Jabalpúr* beds have not as yet been traced with any care in other districts, and I am unable to state their true limits. Their contained fossils point distinctly to a *Jurassic* age and to the lower part of that great period. In the Narbadá nothing but plant-remains have been found. We may, however, although the connection has not been traced, point to the remarkable beds near Kota—about five miles from Sironchá—which have yielded several well-marked fish-remains *(Lepidotus Deccanensis, Æchmodus, &c.)* considered as *Liassic* in their relations, as a probable representative to the south of the *Jabalpúr* beds to the north. There are also some detached patches of rock which occur in the intermediate country which may be representatives of the same general age. The coal found in these *Jabalpúr* beds is very irregularly developed (Sher river; Lametá-ghát). It is jetty, and has much of the character of a true lignite; indeed in many specimens the structure of the now-carbonised stems, of which a large portion of it is made, is well preserved. It has been economised recently to a considerable extent by the contractors on the Great Indian Peninsula Railway. But neither in amount nor in quality does it constitute a source of fossil fuel of any importance in a general view. I mentioned above, that immediately resting on the *Jabalpúr* beds, where the succession is best seen *(South Rewá)*, came the massive sandstones of Bandogarh, which were accepted as representatives of the great *Mahádeo* group, so well seen in the upper and magnificent scarps of the Pachmarhí hills (Central Provinces).

Mahádeo beds.

This *Mahádeo* group was first established after a brief examination of these hills in 1856-57, and was shown to contain a vast thickness of massive sandstones, with many ferruginous bands which *appeared* to be entirely unconformable on the *Damúdá* beds forming the lower ground adjoining. Unfortunately the same name was applied to rocks in other places which showed an approximation to the same general character, and which appeared to stand in the same general relation of an entirely unconformable series above the *Damúdá* rocks. It was from the first indicated that these *Mahádeo* rocks would require further examination. The progress of geological investigation in India has since shown the necessity also of greater sub-division than was at first apparent. These *Mahádeo* rocks, with the exception of a few badly-preserved and generally large stems, are, so far as known, unfossiliferous, and have therefore not attracted quite as much attention as some of the other series I have noticed. This absence of fossils also, and the detached, or comparatively detached, positions in which the *Mahádeo* rocks occur, have rendered the question of their geological age more difficult than it would have otherwise been.* Mr. W. Blanford, carrying up his examination of the country from the west, gave some good reasons for supposing that the *Mahádeo* beds were the continuation and expansion of the cretaceous sandstones found near Bágh in the western Narbadá. A similar general conclusion had been suggested by Mr. Hislop previously, but without much proof. On the other hand, it is right to state that Mr. Medlicott, working up from the east, saw reason for supposing that the *Mahádeo* beds in the Narbadá districts, which he presumed to be truly representative of the Bandogarh rocks in South Rewá (and as a subordinate member of which he considered the *Jabalpúr* beds), were at the same time only an upward extension of the same uninterrupted succession of deposits, which elsewhere had been justly believed to belong to the *Panchet* series.

It will be seen from this that the true position of these beds has not as yet been fixed. When first examined it was by me supposed that they, including the *Lametá* group (to which we shall presently refer), represented the lowest portion of the tertiary period. The Rev. Mr. Hislop, whose untiring exertions have done so much to elucidate the palæontological history of the Central Provinces, was disposed to view them as below all the tertiary deposits, and as representing in India the upper portion of the *cretaceous* epoch of Europe—a view strongly confirmed by Mr. Blanford, who was disposed to put them only a little lower in the series, while Mr. Medlicott would now make them much more ancient, and would place them in the same sub-division as the *Jabalpúr* beds, which latter are probably on the horizon of the Kotá beds—that is, he would consider them *Lower Jurassic.*† As stated, the question cannot at present (January 1870) be definitely settled.

Lametá beds.

When first examining the Narbadá valley Mr. J. G. Medlicott distinguished in the country fringing the river to the south, and between the Mahádeo hills and Jabalpúr, a series of well-marked beds, which he was then disposed to consider as the uppermost group of the *Mahádeo* formation, and to which he applied the local name of Lametá. These *Lametá* beds consisted chiefly of whitish earthy and silicious (cherty) limestones or calcareous muds, often a good deal indurated. These sandy calcareous beds formed only a thin band immediately underlying the trappean rocks. Further and subsequent examination, extending more to the east, proved that this band was entirely independent of the rocks below it, with

* The statement originally made that a very perfect specimen of a true *Archegosaurus* found under the Pachmarhí hills had been obtained from these rocks, was at once refuted by the mineral character of the rock in which it was imbedded. It was from the *Damúdá* beds below.

† The Rájmahál group of Bengal would in this view be of course younger than the Máhádévá of the Central Provinces.

which it was associated, inasmuch as, following the trappean boundary to the south-eastwards, the *Lametá* group was found to accompany the trap-rock steadily and to rest indiscriminately upon all rocks, from the gneiss up. It was therefore clear that it must be viewed as entirely separate from the great *Mahádeo* series, and as intimately connected with the overlying trappean rocks. As noticed above, these *Lametá* beds consist chiefly of cherty and gritty limestones, with subordinate beds of a nodular limestone, loose greenish sandstone, and purplish or greenish argillaceous beds either sandy or marly. They have been traced considerably south of Nágpúr, and thence at intervals round by the trappean boundary to Jabalpúr, and down the Narbadá valley to near Hoshangábád. If Mr. Blanford's views be supported by further examination, the limit must be carried very considerably to the west to the Punásá and the Dhúr forest. In all cases, too, the trap-rocks, where any section is seen, appear to rest quite conformably or continuously on these *Lametá* beds, and beds which cannot be distinguished from them mineralogically are frequently met with interstratified with the traps (as near Nágpúr and between Nágpúr and Jabalpúr).

Intertrappean series.

These remarkable sedimentary beds intercalated with the traps of the Deccan and Málwá areas have received much attention. They constitute the *Intertrappean series* of Hislop, and are interesting from their fossil contents, as well as their mineral character and peculiar stratigraphical position. It would be out of place here to enter into any discussion of the various explanations which have been given of these. It must suffice to say that both in their lithological character [calcareous muds]; in their distribution [local and irregular lenticular masses, not extending laterally to any great distance]; in the fossils contained [fresh-water and lacustrine shells, fragments of plants, &c.], and in their occurrence invariably between the successive flows of trappean rock, the upper surface in all cases being the only one really indurated or altered by the contact of the igneous, heated mass, they indubitably point to their origin in the small and irregular deposits in lakes or pools of varying size, tranquilly thrown down during the intervals of the successive flows of the lava, which now forms the great covering of this immense volcanic region. And I believe that the true explanation of the *Lametá* beds of which I have just been speaking, is that they were deposited in a similar way in more widely-extended lacustrine areas, previously to the commencement of the great outbreaks of lava. It need not detain us here to indicate the apparently long interval of time which elapsed during the outflowing of these successive lava streams, nor to point out how entirely different in age the *intertrappean* beds of the upper part of the series (Bombay, &c.,) may be from those which accompany the lower and older flows. None of these very much newer beds occur within the limits of the Central Provinces.

The geological epoch of these intertrappean beds seems to be tolerably well established as belonging to the *Eocene* period of European geologists; it being just possible that the lower beds of the *Lametá* group may represent a part of the upper cretaceous time. The evidence against this supposition of Mr. W. Blanford seems, however, decidedly stronger than that in its favour.

Deccan trap features.

The wondrous features of the great trappean country of the Deccan which extend over so large a portion of the surface of the Central Provinces, have been well described by many observers. The immense area covered continuously by these volcanic rocks; the enormous accumulation of horizontal, or nearly horizontal, layers of basaltic rocks; the distinct separation into beds, or stratification; the peculiar physical features,—massive flat-topped hills with sharp precipitous scarps; the abundance of beautiful zeolites and other minerals, and the occurrence of those curious intercalated beds, containing fresh-water fossils, which I have just mentioned, could scarcely escape the notice of any observer. I have already briefly alluded to the general distribution of these rocks, so far as the Central Provinces are concerned, and shall not therefore delay further than to refer to the labours of Malcolmson, Newbold, Grant, Carter, Hislop, Medlicott, Blanford, &c., for more detailed discussions of this extraordinary series, which extends, or has extended, certainly over an area of 10 degrees of latitude by 15 to 16 of longitude. "The area covered by them in the Peninsula of India can be little "less than two hundred thousand square miles." Their limited extent within the boundaries of the Central Provinces is therefore but a very small fraction of their entire area.

Post-trappean deposits.

Of deposits later than the trappean rocks there is a great variety and an immense area. These would include all the soils of the present surface with their numerous modifications and varying agricultural value.

Laterite occurs in detached areas in Ságar and adjoining districts; it covers a considerable space in the north-east of Jabalpúr district, and is found at intervals passing to the south in Chándá, where it covers extensive areas in the eastern and north-eastern portions. It presents all the usual characters of this deposit, but nowhere within the Central Provinces attains that great thickness and massiveness which admit of its being freely used for building purposes.

Tertiary conglomerates.

The older gravels and clays of some of the river valleys would appear to be next in succession. These have been the object of more careful study, on account of the numerous remains of large animals, as well as ordinary shells, of which some of the beds contain locally in large number. The largest continuous area of these ossiferous gravels and clays is found in the Narbadá valley, along which they extend in unbroken continuity for more than a hundred miles from the falls of the 'marble rocks' near Jabalpúr to below Hoshangábád. They also occur in the banks of the river both above and below these limits. Very similar deposits are found forming the banks and often the beds of the upper feeders of the Godávarí—the Wardhá, Paingangá, &c.—and in the Godávarí itself; and here also they locally contain a large number of bones, sub-fossilised, the remains of animals which existed at the period of their deposition. The valleys of these streams are, however, by no means so well defined as that of the Narbadá, and the limits of the ossiferous gravels and clays are not easily fixed. The gravels are for the most part cemented into a conglomerate of tolerable hardness by the infiltration of carbonate of lime, and these beds might not unfrequently be mistaken for conglomerates of greatly older date on a cursory examination. There is, however, one fact which enables them to be readily distinguished, and that is the abundant presence in them of rolled pieces of the trappean rocks—of numerous agates, pieces of bloodstone, &c., which at once prove them to have been post-trappean in their origin. The immense variety and abundance of these pebbles also abundantly indicate the vast denudation to which the trappean rocks have been subjected since their outflowing and deposition.

Ossiferous gravels.

In general character these deposits in their lower portions consist of gravels and sands, frequently, as mentioned, cemented together much in the same way as a concrete is, and sometimes so hard as to be quarried for building. Towards the base the clays become sandy and pebbly. Sandy beds occur even in the clays, and irregular deposition and oblique lamination (false-bedding) are frequent—indeed so frequent as to be almost the normal condition. It is not easy to arrive at any just conclusion as to the thickness of these deposits. Actual sections of more than fifty feet in thickness are occasionally met with, but twenty to thirty feet are the more ordinary limits. The greater portion of the deposits is generally clay, the coarser beds being chiefly confined to the portion near the base. Fossil bones are not generally abundant, but locally considerable numbers have been met with. Shells are not uncommon, and they appear to be all of species now existing in the rivers. These beds are obviously of fresh-water origin, and were in all probability the fluvio-lacustrine deposits of the rivers themselves, at a time when the levels and areas of their valleys were very different from those now existing.

It is not intended to give here a complete list of the organic remains found, which would belong rather to a detailed description. But the very remarkable admixture of existing and extinct forms which these deposits exhibit must be noticed; for along with well-preserved remains of *Hippopotamus, Rhinoceros, Mastodon,* peculiar forms of *Elephas,* and very remarkable Bovines (which, if not identical with European forms, approximate so closely that nothing but the most minute distinctions can be made, while they are entirely distinct from any present Indian forms), are found equally well preserved remains of animals still existing in the country. The not uncommon tortoise* *(Emys [Pangshura] tecta)* is found quite as fossilised in these beds as any of the other remains, and yet the species still lives in the valley itself. The imbedded shells, too, are all of species still living, and the evidence is conclusive that the change from the condition under which *Hippopotami* wallowed in the muds, and *Rhinoceros* roamed in the swampy forests of the country, where *Mastodons* abounded, and where the strange forms of the *Sivatherium, Dinotherium, Camelopardalis* existed, has been one of continuous and gradual alteration, unmarked by any great breaks or vast changes in climate. In the general series of successive epochs into which the geological periods distinguished in Europe have been classified, these ossiferous gravels and clays would seem to mark the upper portion of the *Miocene* and the *Pliocene;* while, with unbroken succession, and with nothing more than local change or break, these *Pliocene* beds pass upwards into the deposits now being formed. We thus find that numerous forms of animals, which are now contemporaries of man, existed at this very early period cotemporary with numerous forms of the larger animals now utterly extinct in this country. Was not man also cotemporary with these now extinct animals? As I have now endeavoured to show briefly, there is no physical break in the long series that would account for the destruction of these species; there is not a shadow of proof that the country was not then, as now, fitted for the abode of man. And although no human remains have yet been found, there is not a single fact which would lead to the conviction that man could not have existed and lived under the conditions which then prevailed. In this point of view, the discovery—although not in the Central Provinces—of a well-formed agate knife,† which had obviously been in use, and which was undoubtedly shaped and made with an intelligent purpose, in gravels of the same age as these ossiferous gravels of which we have been speaking and also containing remains of large animals, becomes one of the highest interest, as giving some amount of positive proof of the existence of man at this early period *(Pliocene).*

Stone implements.

Of a later date, and scattered through the upper soils of large areas, flint (or rather agate) knives, agate cores, from which these knives have been chipped off, and numerous forms of artificially-shaped agate implements, have been met with in the Narbadá and Nágpúr country. And of a later date still, and invariably in the surface-soils, or taken out of these soils and brought together under trees, or at the rude shrines of the forest races, a large number of well-shaped and *polished* celts, axes, and other shaped stone implements have been found in the Central Provinces. The most remarkable fact perhaps connected with these implements is the identity of form and of design which they exhibit when compared with those found abundantly in Northern Europe—an identity common to both forms of these stone antiquities, the rudely-chipped and almost undressed, or, as they have been called, the Palæolithic, and the more finished and polished, or Neolithic, types.

* See Records Geological Survey of India, 1869, p. 36. † *Ibid,* 1868, p. 65.

The Central Provinces present many localities peculiarly likely to throw light, if carefully studied, on this intensely interesting question—the antiquity of man. But such inquiries can only be satisfactorily carried out by those who are long resident in the immediate vicinity, and can therefore watch the constant changes which occur, and take immediate advantage of any opportunity which may present itself.

Saline sands and clays.

Beneath the recent conglomerates and ossiferous gravels of a large portion of western Chándá is a well-marked deposit of brownish-yellow sand or clayey sandstone. This is seen over many miles of the country wherever the streams cut through the upper beds to any depth. It is not at all improbable that it may prove to be of different geological age, and quite distinct from the beds resting on it. No good sections have yet been seen. It is specially noticed here inasmuch as it contains a certain amount of salt, which is thrown out as an efflorescence where this loose sandstone is exposed to the weather, and produces miry places always wet and soft, and often difficult to cross. In connection with this deposit we may recall the occurrence of beds very low down in the alluvium, or below it, all containing a considerable quantity of common salt, in the Berár alluvial plain not far to the west of Chándá. Into this salt-bearing stratum wells are sunk for the extraction of brine, from which much salt is obtained. I am not aware of any brine-wells in the Chándá district, but this deposit contains a considerable amount of common salt, although much mixed with impurities, chiefly sulphate of magnesia (Epsom salts).* It is not impossible that the presence of common salt in sensible quantities may indicate that the clays containing it have had a marine origin, and are thus quite distinct from the beds which rest upon them.

Surface soils.

To treat of the more recent alluvial deposits of the country would involve rather more of agricultural than geological questions, and I would leave such to others more competent to enter upon them.

Regar.

The black soil or *regar*, or as it is not uncommonly called the 'cotton soil,' forms one of the most marked varieties in these provinces. It is the common soil of the Deccan, Málwá, Narbadá valley, &c. It varies greatly in colour, in consistence, and, with these, in fertility, but throughout is marked by the constant character of being a highly argillaceous, somewhat calcareous clay, being very adhesive when wetted, and from its very absorbent nature expanding and contracting to a very remarkable extent, under the successive influence of moisture and dryness. It therefore becomes fissured in every direction by huge cracks in the hot weather. It also retains a good deal of moisture, and requires therefore less irrigation than more sandy ground. The colour of this soil, often a deep and well-marked black, with every variation from this to a brownish-black, would appear to be solely due to an admixture of vegetable (organic) matter in a soil originally very clayey. Thus deposits of precisely the same character as this *regar* are being formed now at the bottom of every *jhíl* in the country, and throughout the very area where the *regar* is best marked, it is not by any means an uncommon thing to find the slopes of the small hills or undulations formed

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* Two specimens of salt roughly prepared from this sandy clay by lixiviation and evaporation were assayed at the Geological Survey Office, and yielded—

Chloride of sodium	82·89	87·58
Sulphate of magnesia	16·02	11·86
Clay and organic matter	1·60	1·40

The first of these was obtained from what is called the white *chopan* soil; the second was from the dark *chopan* soil.

of more sandy reddish soil, while the hollows below consist solely of the finest *regar*. This appears to be due to the more argillaceous and finer portions of the decomposed rocks below being washed away by ordinary pluvial action from the slopes and accumulated in the hollows, where this finer mud forms a soil much more retentive of moisture, and which therefore rapidly becomes more impregnated with organic matter, and is often marshy. *Regar* can thus be formed wherever a truly argillaceous soil is formed: and its general, but by no means universal, absence over the metamorphic and other rocks is easily accounted for by the fact that these rocks for the most part yield sandy, not clayey soils. It is never of any very great depth, and, excepting when re-arranged by rivers in their recent deposits, it is therefore never met with at any great distance below the surface.

Obviously formed from the re-arranged wash of the older and more widely-extended soils we find large areas of very fertile soil, consisting of clays rather more sandy than the older alluvium, and not therefore so black or adhesive. Though rarely formed altogether of the true *regar* soil, it frequently contains a large proportion of this, mixed with other clays and sands. Every intermediate form of soil occurs, and it would by no means be an easy task to distinguish them all. In an agricultural point of view, it is interesting to see how exactly the limits of certain kinds of cultivation coincide with the limits of these marked varieties of the alluvial deposits of the country—facts which the local officers will doubtless be able to illustrate more fully than I can.

The preceding sketch has necessarily been of the briefest and most general character. Those who desire to study the geology of the Central Provinces in greater detail may refer to the many papers more or less immediately bearing on this country—of Malcolmson, (Transactions, Geol. Soc., Lond.); Hislop (Journal of Asiatic Society, Bengal; Journal of Bombay Branch Royal Asiatic Society; Quarterly Journal Geological Society, London); Medlicott, Oldham, Blanford, Theobald, (Mem. Geological Survey of India; Records Geological Survey of India), in which full details will be found so far as the country has yet been examined carefully.

I shall also leave the discussion of the economic value of the several rocks to the detailed statements of the local officers, who have infinitely better opportunity of knowing how and to what extent such materials are economised within their own districts. I have solely attempted to give as briefly as possible a general connected outline of the successive formations known to occur within the limits of the Central Provinces, trusting that this outline may be filled in with greater detail by future researches.

N. B.—The following papers bearing on the Geology of the Central Provinces have been published since the foregoing was written:—

The coal-field near Chándá, Central Provinces.—Records, Geol. Surv., India, 1869, p. 94.
Lead in Ráípúr district, Central Provinces.—*Ibid*, p. 101.
On the lead vein near Chicholi, Ráípúr district.—*Ibid*, 1870, p. 44.
The Wardha river Coal-fields, Berar and Central Provinces.—*Ibid*, p. 45.
Coal at Korba in Bilaspúr district.—*Ibid*, p. 54.
Mohpani Coal-field.—*Ibid*, p. 63.
Lead ore at Slimanabad, Jabalpúr district.—*Ibid*, p. 70.
Coal east of Chhattisgarh in country between Bilaspúr and Ranchí.—*Ibid*, p. 71.
The plant-bearing sandstones of the Godávarí valley; on the southern extension of rocks belonging to the Kámthí group to the neighbourhood of Ellore and Rájámandrí, and on possible occurrence of coal in same direction.—*Ibid*, 1871, p. 49.

ADDITIONAL NOTE ON THE PLANT-BEARING SANDSTONES OF THE GODÁVARÍ VALLEY, *by* W. T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

Since writing the paper in this volume of the "Records," p. 49, I have found that the occurrence of sandstone near Ellore was mentioned by Voysey, Jour. As. Soc., Bengal, Vol. II, 1833, p. 400. Both Voysey and Walker refer in several places to the occurrence of sandstone in the valley of the Godávarí below Sironchá, so that Wall was not the first to make it known, although he appears to have been the first who explored its extent on the river banks. In explanation of my mistake, I should mention that my paper was written when I was encamped on the Godávarí without a single book of reference available.

I have also ascertained that the sandstone which extends to the neighbourhood of Ellore is connected with the large tract to the north-west by a narrow strip about six miles broad to the west of Palúncha, thus confirming Voysey's statement on the authority of a Mr. Ralph (Jour. As. Soc., Bengal., Vol. XIX, p. 290). The sandstones, therefore, extend, apparently without a break, from Mangli and Phizdúra, 60 miles south of Nágpúr, to within a few miles of Ellore, or nearly 300 miles in a direct line.

The boundaries of this enormous tract are in many parts most imperfectly known: by far the greater portion of the area consists of rock in which no trace of coal has hitherto been detected, and in which the occurrence of the mineral is highly improbable. It is along the edges that there is the best chance of valuable discoveries being made.

Since writing the paper above alluded to, I have visited Alápali, a village about thirty miles west of Dúmagúdem on the Kinarswámi stream, at which I had been informed by one of the officers of the Nizam's Government, the Naib of Naganienpol, that some coal had been discovered. Mr. Vanstavern, Executive Engineer of Dúmagúdem, had, at my request, sent some specimens of the coal found at Lingálá to the Naib for distribution amongst the minor officials, and for enquiry as to the occurrence of a similar mineral throughout the great sandstone country on the right bank of the Godávarí. This resulted in a report of the occurrence of coal near Alápalí, but on visiting the spot, I found that all which had been found consisted of fragments brought down by the stream. I had not time to trace these to their source, and this was the less necessary, as I found that an officer of the Nizam's Government had been sent from Warangal in order to do so. I have since been informed by the Tehsildár of Kamarmet that the spot has been found. It is some distance to the east of Paikhal on the confines of the Kamarmet and Warangal Sircars. This discovery will not be of much value at present if any permanent supply can be found on the Godávarí below the second barrier, but should no such supply exist, the locality near Paikhal will be well worthy of attention. The fragments of coal found in the Kinarswámi are shaly and of inferior quality, but where this exists better coal may, of course, be found.

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ANGELIN, N. P.—Palæontologia Scandinavica, Part I. Crustacea Formationis Transitionis, 4to., 1854, Lipsiæ.

ARGYLL, DUKE OF.—The Reign of Law, 8vo., 1870, London.

BASTERI, JOBI.—Opuscula Subseciva, observationes miscellaneas de animalculis et plantis continentia, Vols. I-II, (1762,) 4to., 1762, Haarlem.

BŒTTGER, OSKAR.—Beitrag zur palæontologischen und geologischen Kenntniss der Tertiär-formation in Hessen, 4to., 1869, Offenbach.

BRANDER, GUSTAV.—Fossilia Hantoniensia collecta et in Musæo Britannico Deposita, 4to., 1766, Londini.

BRAUN, F.—Verzeichniss der in der Kreis Naturalien-Sammlung zu Bayreuth befindlichen Petrefacten, 4to., 1840, Leipzig.

CATALOGUE of Scientific Papers published by the Royal Society of London, Vol. III, (1869,) IV, (1870,) 4to., 1869-70, London.

CATLIN, GEO.—The Lifted and Subsided Rocks of America, 8vo., 1870, London.

CATULLO, TOMASO ANTONIO.—Dei Terreni di Sedimento Superiore delle Venezie e dei Fossili Bryo-zoari, Anthizoari e Spongiari ai quali danno Ricetto Memoria; 4to., 1856, Padova.

COSTA, Prof. O. G.—Palæontologia del Regno di Napoli continente la Descrizione e figura di tutti gli avanzi Organici Fossili, Pts. I-II, (1850,) 4to., 1850, Napoli.

DESCRIPTION DE L'EGYPTE, Vol. XX, (1825,) XXI, (1826,) 8vo. Geol. et Miner. with plate, folio, 1825-26, Paris.

DESHAYES, M. G. P.—Description de Coquilles Caractéristiques des Terrains, 8vo., 1831, Paris.

DOLLFUS, A., and MONT-SERRAT, E. DE.—Mission Scientifique au Mexique et dans L'Amérique Centrale. Géologie. Voyage Géologique dans Républiques de Guatemala et de Salvador, 4to., 1868, Paris.

DONALDSON, J.—Report on the utilization of iron-making materials in the neighbourhood of Hazareebaugh by means of convict labour, flsc., 1870, Calcutta.
V. BALL, Esq.

FŒTTERLE, FRANZ.—Das Vorkommen, die Production und Circulation des Mineralischen Brennstoffes, 8vo., 1870, Vienna. THE AUTHOR.

FORWOOD, W. STUMP.—An Historical and Descriptive Narrative of the Mammoth Cave of Kentucky, 8vo., 1870, Philadelphia.

FRAAS, DR. OSCAR.—Die Fauna von Steinheim, 4to., 1870, Stuttgart.

FRITSCH, K., v.-REISS, W., and STÜBEL, A.—Santorin. The Kaimeni Islands, 4to., 1867, London.

GRAS, SCIPION.—Statistique Minéralogique du Département de la Drôme, 8vo., 1835, Grenoble.

HAYDEN, DR. F. V.—Geological Report of the exploration of the Yellowstone and Missouri Rivers, 1859-60, 8vo., 1869, Washington.

HAYDEN, F. V.—Preliminary Field Report of the United States Geological Survey of Colorado and New Mexico, 8vo., 1869, Washington.

HIND, HENRY YOULE.—Report on the Sherbrooke Gold District, with a Paper on the Gneisses of Nova Scotia, 8vo., 1870, Halifax.

Titles of Books. *Donors.*

HITCHCOCK, EDWARD.—Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts, 8vo., 1833, Amherst.

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IRVINE, ASS. SURG. ROBERT HAMILTON.—Some account of the General and Medical Topography of Ajmeer, 8vo., 1841, Calcutta.

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LAPEIROUSE, PICOT DE.—Déscription de plusieurs nouvelles espéces d'Orthocératites et d'Ostracites, fol. 1781, Erlang.

LYMAN, BENJAMIN SMITH.—General Report on the Punjab Oil Lands, flsc., 1870, Lahore.

MORRIS, JOHN, and JONES, T. RUPERT.—Geology, 8vo., 1870, London.

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PIDGEON, EDWARD.—The Fossil Remains of the Animal Kingdom, 8vo., 1830, London.

REYNÉS, P.—Essai de Géologie et de Paléontologie Aveyronnaises, 8vo., 1868, Paris.

ROEMER, DR. FERD.—Géologie von Oberschlesien. With Plates and Atlas, 8vo., 1870, Breslaw.

SCHUMANN, JULIUS.—Geologische Wanderungen durch Alt-Preussen, 8vo., 1869, Königsberg.

SCHVARCZ, JULIUS.—The failure of geological attempts made by the Greeks from the earliest ages down to the epoch of Alexander, 4to., 1868, London.

SOBRERO, ASCANIO.—Notizia Storica dei Lavori Fatti dalla classe di Scienze Fisiche e Matematiche della Reale Accad. d. Scienze d. Torino, 1864-65, 8vo., 1869, Turin. THE TURIN ACADEMY.

THOMSEN, JULIUS.—Thermochemiske Undersœgelser, IX, Undersœgelser over vandige Oplœsningers Varmefylde, 4to., 1870, Copenhagen. THE DANISH ACADEMY.

WARD, J. CLIFTON.—Ice, and a Geological Dream on Skiddaw, 8vo., 1870, London.

PERIODICALS.

American Journal of Science and Arts, 3rd ser., Vol. I, Nos. 1-4, 8vo., 1871, New Haven.

Annales des Mines, 4th ser., Vol. VI, Liv. 5, 8vo., 1844, Paris.

Annals and Magazine of Natural History, 4th ser., Vol. VII, Nos. 37-41, 8vo., 1871, London.

Annals of Indian Administration, Vol. XV, Pt. I, 8vo., 1871, Serampore. GOVERNMENT OF INDIA.

BASTIAN, A., and HARTMANN, R.—Zeitschrift für Ethnologie, Band II, Heft. 5-6, 8vo., 1870, Berlin.

Geological Magazine, Vol. VIII, Nos. 1-4, 8vo., 1871, London.

Indian Economist, with Agricultural Gazette and Statistical Reporter, Vol. II, Nos. 9-11, 4to., 1871, Calcutta. GOVERNMENT OF INDIA.

KOLDEWEY, K., and PETERMANN, A.—Die Erste Deutsche Nordpolar-Expedition, 1868, 4to., 1871, Gotha.

LEONHARD, G., and GEINITZ, H. B.—Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Heft. I—II, 8vo., 1871, Stuttgart.

MARTINI UND CHEMNITZ.—Systematisches Conchylien-Cabinet, Bd. X, Heft. 9, 4to., 1870, Nurnberg, 4to., 1837-41, Neuchatel.

Titles of Books. *Donors.*

PETERMANN, DR. A.—Geographische Mittheilungen, Band XXVII, Nos. 1-4, 4to., 1871, Gotha.

PFEIFFER, DR. LOUIS.—Malakozoologische Blätter, Band XVII, Bg. 6-8, 8vo., 1870, Cassel.

The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 4th Series, Vol. XLI, Nos. 270-74, 8vo., 1871, London.

GOVERNMENT SELECTIONS.

BENGAL.—VANRENEN, COL. D. C., and MACDONALD, MAJOR J.—General Report on the Revenue Survey Operations of the Bengal Presidency, Upper and Lower Circles, for season 1869-70, flsc., 1871, Calcutta.

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GOVERNMENT OF BRITISH BURMAH.

INDIA.—Selections from the Records of the Government of India, Foreign Department, No. LXXXII, 8vo., 1870, Calcutta. GOVERNMENT OF INDIA.

" WALKER, COL. J. T.—General Report on the operations of the Great Trigonometrical Survey of India during 1869-70, flsc., 1870, Dehra Doon.

HOME OFFICE.

MADRAS.—Selections from the Records of the Madras Government, No. XXII. Papers relating to the Survey and Settlement of the Western Delta Talooks of the Godavery District, 8vo., 1870, Madras.

GOVT. OF MADRAS, HOME DEPT.

JOURNALS, TRANSACTIONS.

BERLIN.—Monatsbericht der königlich Preussischen Akademie der Wissenschaften zu Berlin, January to March, 8vo., 1871, Berlin. THE ACADEMY.

CALCUTTA.—Journal of the Agricultural and Horticultural Society of India, New Ser., Vol. II, pt. II, 8vo., 1871, Calcutta. THE SOCIETY.

" Proceedings of the Asiatic Society of Bengal, Nos. 3-6, 8vo., 1871, Calcutta.

THE SOCIETY.

" Records of the Geological Survey of India, Vol. IV, Pt. II, 8vo., 1871, Calcutta.

THE SURVEY.

" Transactions of the Medical and Physical Society of Calcutta, Vol. I (1825)—IX, Pt. I, (1845,) 8vo., 1825—45, Calcutta.

COPENHAGEN.—STEENSTRUP, J. J. SM.—Oversight over det kongelige danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider i Aaret, 1868-70, No. 6, (1868,) No. 4, (1869,) No. 1, (1870,) 8vo., 1868-70, Copenhagen. DANISH ACADEMY.

EDINBURGH.—Proceedings of the Royal Society of Edinburgh, session 1869-70, Vol. VII, No. 80, 8vo., 1870, Edinburgh. THE SOCIETY.

" Transactions of the Royal Society of Edinburgh, Vol. XXVI, Pt. I, 4to., 1870, Edinburgh. THE SOCIETY.

Titles of Books. *Donors.*

FLORENCE.—Bollettino R. Comitato Geologico D'Italia, Nos. 1-4, 8vo., 1871, Florence.
THE COMMISSION.

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GLASGOW.—Proceedings of the Philosophical Society of Glasgow, Vol. VI, Nos. 2-4, (1866-68), Vol. VII, Nos. 1-2, (1869-70,) 8vo., 1866-70, Glasgow.
THE SOCIETY.

LONDON.—British Museum. A Guide to the Collection of Minerals, 8vo., 1870, London.
TRUSTEES, BR. MUSEUM.

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TRUSTEES, BRITISH MUSEUM.

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TRUSTEES, BR. MUSEUM.

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TRUSTEES, BR. MUSEUM.

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" GRAY, GEORGE ROBERT.—Catalogue of British Birds in the Collection of the British Museum, 8vo., 1863, London. TRUSTEES, BR. MUSEUM.

" GRAY, GEORGE ROBERT.—Hand-List of Genera and Species of Birds, distinguishing those contained in the British Museum, Pt. I, (1869,) 8vo., 1869, London. TRUSTEES, BR. MUSEUM.

" GRAY, GEORGE ROBERT.—List of the Specimens of Birds in the collection of the British Museum, Pt. III, Section 3-4, 12mo., 1867-68, London.
TRUSTEES, BRITISH MUSEUM.

" GRAY, JOHN E.—Catalogue of Carnivorous, Pachydermatous and Edentate Mammalia in the British Museum, 8vo., 1869, London.
TRUSTEES, BRITISH MUSEUM.

" GRAY, JOHN E.—Catalogue of Lithophytes, or Stony Corals, in the collection of the British Museum, 8vo., 1870, London.
TRUSTEES, BRITISH MUSEUM.

" GRAY, JOHN EDWARD.—Catalogue of Seals and Whales in the British Museum, 8vo., 1866, London. TRUSTEES, BRITISH MUSEUM.

" GRAY, JOHN E.—Catalogue of Sea-Pens or Pennatularidæ in the collection of the British Museum, 8vo., 1870, London.
TRUSTEES, BRITISH MUSEUM.

" GRAY, JOHN E.—Supplement to the catalogue of Shield Reptiles in the collection of the British Museum, Pt. I, Testudinata (Tortoises), 4to., 1870, London. TRUSTEES, BRITISH MUSEUM.

" GUNTHER, ALBERT.—Catalogue of the Fishes in the British Museum, Vol. V, (1864,) VIII, (1870,) 8vo., 1864-70, London.
TRUSTEES, BRITISH MUSEUM.

" JOHNSTON, GEORGE.—A catalogue of the British Non-Parasitical Worms in the collection of the British Museum, 8vo., 1865, London.
TRUSTEES, BRITISH MUSEUM.

Titles of Books. *Donors.*

LONDON.—List of the Mollusca in the collection of the British Museum, Pt. II, Olividæ, 12mo., 1865, London. TRUSTEES, BRITISH MUSEUM.

„ WALKER, FRANCIS.—Catalogue of the Specimens of Blattariæ in the collection of the British Museum, 8vo., 1868, London. TRUSTEES, BRITISH MUSEUM.

„ WALKER, FRANCIS.—Catalogue of the Specimens of Dermaptera Saltatoria and Supplement to the Blattariæ in the collection of the British Museum, Pt. I, (1869,) III, 1870, 8vo., 1869-70, London. TRUSTEES, BRITISH MUSEUM.

„ WALKER, FRANCIS.—Catalogue of the Specimens of Hemiptera Heteroptera in the collection of the British Museum, Pt. I, (1867,) III, (1868,) Scutata, 8vo., 1867-68, London. TRUSTEES, BRITISH MUSEUM.

„ WALKER, FRANCIS.—List of the Specimens of Lepidopterous Insects in the collection of the British Museum, Pt. XXVII, (1863), XXX, (1864,) Crambites, Tortricitæ and Tineites, 12mo., 1863-64, London. TRUSTEES, BRITISH MUSEUM.

„ WALKER, FRANCIS.—List of the Specimens of Lepidopterous Insects in the collection of the British Museum, Pt. XXXI, Supplement I, (1864,) Pt. XXXV, Supplement V, (1866,) 12mo., 1864-66, London. TRUSTEES, BRITISH MUSEUM.

„ WOLLASTON, T. VERNON.—Catalogue of the Coleopterous Insects of the Canaries in the collection of the British Museum, 8vo., 1864, London. TRUSTEES, BRITISH MUSEUM.

„ Journals of the Royal Asiatic Society of Great Britain and Ireland, New Ser., Vol. V, Pt. I, 8vo., 1870, London. THE SOCIETY.

„ Royal Society. Philosophical Transactions of the, London, Vol. 160, pts. 1-2, with list of members, 4to., 1870, London. THE SOCIETY.

„ Proceedings of the Royal Society of London, Vol. XIX, Nos. 125 and 127, 8vo., 1870, London. THE SOCIETY.

„ Quarterly Journal of the Geological Society of London, Vol. XXVII, Pt. I, No. 105, 8vo., 1871, London THE SOCIETY.

„ Journal of the Society of Arts, Vol. XIX, Nos. 949-955, 8vo., 1871, London. THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute, Vol. LX, Nos. 5-6, 8vo., 1870, Philadelphia. THE INSTITUTE.

TRINIDAD.—Proceedings of the Scientific Association of Trinidad, Pt. I, December (1866,) to VII, June, (1869,) 8vo., 1866-69, Port-of-Spain.

TURIN.—Atti della R. Accademia delle Scienze di Torino, Vol. V, (1869-70,) and Appendice al Volume IV. Degli atti della R. Accademia delle Scienze di Torino, 8vo., 1869-70, Turin. THE ACADEMY.

„ Bolletino Meteorologico ed Astronomico del Regio Osservatorio dell' Universita di Torino. Anno. IV, 4to., 1869, Turin. THE ACADEMY.

VIENNA.—Jahrbuch der k. k. Geologischen Reichsanstalt, Band XX, Nos. 2-4, 8vo., 1870, Vienna. THE INSTITUTE.

„ Verhandlungen der k. k., Geologischen Reichsanstalt, Nos. 6-18, 8vo., 1870, Vienna. THE INSTITUTE.

Titles of Books. *Donors.*

VIENNA.—Verhandlungen der k. k., Zoologisch-botanischen Gesellschaft in Wien. Band XX, 8vo., 1870, Vienna.

WELLINGTON.—Transactions and Proceedings of the New Zealand Institute, Vol. I, (1868,) II, (1869,) 8vo., 1869-70, Wellington.

ZURICH.—Neue Denkschriften der Allg. Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Band I, (1837,)—V, (1841,) Zurich.

MAPS.

HAUER. FRANZ RITTER VON.—Geologische Uebersichts karte der Oesterreichisch-ungarischen Monarchie. Blatt, No. III, Westkarpathen. Fol. with description, 8vo., 1869, Vienna.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1872. [August.

NOTE ON MASKAT AND MASSANDIM ON THE EAST COAST OF ARABIA, *by* W. T. BLANFORD, A. R. S. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

The rocks of Maskat and of Rás Massandim, (the latter being the bold projecting cape which forms the Arabian side of the straits of Hormuz at the entrance to the Persian Gulf,) have already been described by Dr. Carter in his memoir on the geology of the south-east coast of Arabia; the former from personal inspection, the latter from specimens and a description furnished by Lieutenant Constable. In a recent voyage up the Persian Gulf, I had an opportunity of visiting both these localities, and the result of my brief examination of them, whilst entirely confirming Dr. Carter's account, enables me to add a few particulars of interest.

Maskat.—The cove of Maskat, as mentioned by Dr. Carter, is surrounded by dark coloured serpentine rocks rising steeply from the water. But here and there stratification or foliation is very apparent; thus, on the west side of the harbour, the rocks have a distinct dip to the north at an angle of about 45°. Riding inland from the suburb of Matrah to a distance of two or three miles, I found that the serpentine passes gradually into hornblende-schist,* and I can only suggest that the rocks of Maskat probably belong to the metamorphic series, which is mentioned by Carter as occurring in the form of granite, gneiss, diorite, &c., at several places on the south-east coast of Arabia.

Upon the schists and serpentine rest beds of pale-coloured limestone, with calcareous sandstones, conglomerate and variegated clays with gypsum, just as described by Carter. The conglomerate contains pebbles of limestone, sandstone, quartzite, and a green quartzose rock coloured by chlorite. Amongst the limestone pebbles, some of a very dark colour contain traces of fossils resembling encrinite stems; these are perhaps derived from rocks of the same series as those of Massandim.

I could find no fossils in the limestones, &c., at the place where I examined them, but their appearance is so similar to that of some of the nummulitic rocks of Sind that I should have classed them as probably nummulitic, even without the conclusive evidence furnished by Captain Newbold.† At the same time it struck me that some greyish overlying beds which I had not time to visit, but which are well seen on the coast north-west of Maskat, might belong to the newer tertiaries of the Makrán group.‡ The little island of Fahil appears to be of nummulitic limestone.

Massandim.—The whole of the promontory which, jutting out from the Arabian Coast, closes in the southern portion of the Persian Gulf appears to consist of stratified dark-

* It is doubtless a less schistose form of this rock which Dr. Carter calls diorite.

† Jour. Bombay Br. R. A. S., Vol. III, pt. 1, p. 27.

‡ See previous paper, p. 48, for the meaning of this term.

coloured limestone. I had an opportunity from the deck of the steamer of seeing the cape itself and the little island of Massandim, from which the whole promontory derives the name by which it is chiefly known.

Subsequently in Khor-as-Shem, or Elphinstone Inlet of the old charts, formerly a telegraph station of the Persian Gulf Cable, I was enabled to examine the rocks more closely.

They consist of black, brown, dark-grey, and dark-buff limestone, hard, compact, and intersected by veins of calcite, with a few comparatively thin and subordinate beds of shale and sandstone. These rocks are distinctly stratified, the slight variations in the colouring of the different beds rendering the stratification distinct up to the very summit of the huge precipitous mountains which rise from the shores of the inlet. As a rule, the beds roll about with a moderate dip not exceeding 20°; in places there is much disturbance and contortion. The thickness of the beds must be very great; some of the mountains on the inlet are said to be 6,000 feet high, and they evidently consist entirely of the dark limestone; indeed no trace of any other rock was to be seen in the neighbourhood.

Fossils are far from scarce in the limestone, but it is unusually difficult to find any in a state in which they can be recognised. Sections of shells, both univalves and bivalves, fragments of corals, and apparently of encrinites, are to be found in several beds, but it was only after much search that I found anything which may possibly be identified.

These fossils have been submitted to careful examination by Dr. F. Stoliczka, Palæontologist to the Geological Survey of India, who states: "The limestone contains several specimens of a *Myophoria*, externally very closely resembling *M. chenopus*, Laube, from the St. Cassian beds, and indicating upper triassic strata. This is the only fossil which can be even approximately determined. It occurs socially, and together with some casts of *Gastropoda*, resembling *Chemnitzia*.

"A few casts of a Pelecypod resemble in shape *Anoplophora*, also a triassic genus." There are two valves of an *Exogyra* of the shape of the neocomien *E. conica*. As far as I know, this type is unknown in the Trias.

"A few fragments of a Pecten, undeterminable, occur; and several fragments of an Asteroid coral."

I suspect that this great limestone-formation must occupy a considerable area in 'Omán; and it is far from improbable that it forms part of the great dark-coloured mountain ranges behind Maskat. This is the more probable, because Dr. Carter obtained through Mr. Cole of the Indian Navy specimens of similar limestone from the mountains near Rás-el-Had.

The most remarkable circumstance about the Massandim promontory is its form. The inlet I visited, Khor-as-Shem, runs from the Persian Gulf for, I believe, seventeen miles into the heart of the hills; it is about 17 to 20 fathoms deep throughout, and in many places even close up to the rocks on each side. It is only separated by a belt of land less than a mile broad from another inlet called Ghubet Ghúzirah (Malcolm's Inlet of the old charts), which enters from the eastern side of the promontory in the Gulf of 'Omán, and which is still deeper. Other inlets occur, all very deep, and immediately off the rocky coast is the deepest part of the Persian Gulf. There is a curious resemblance of these inlets to the fiords of Norway, but the latter are undoubtedly of glacial origin, whilst no such cause can be suggested in one of the very hottest regions of the whole surface of the globe. The sea could never excavate such land-locked basins as that of Khor-as-Shem, barely a mile across in places and 20 fathoms deep. I can only suppose that the peculiar form of this coast is the result of subsidence, that the inlets were valleys on the land produced in the usual manner by rain and streams and then sunk beneath the sea. The great depth of the Gulf of 'Oman off Maskat (2,000 fathoms) may point to a general and long continued subsidence along this coast, and, if so, it is curious to contrast it with the evidence of comparatively recent elevation on the opposite shores of Persia as noticed in a previous paper.

CAMP GWADAR, BILUCHISTAN; *January*, 1872.

AN EXAMPLE OF LOCAL JOINTING, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Within the cantonments of Jabalpúr, south of the civil station and of the city, there is a small group of hillocks, or steep bare rock-masses, about fifty feet in height. The whole stand within an area of nearly one hundred and fifty acres, of which the protruding rock occupies about two-thirds, in three principal masses. They are locally known as the Kattungá quarries; the sandstone being much valued and extensively worked for building stone. Its use for this purpose is greatly facilitated by the very perfect jointing by which the rock is traversed. The unique character of this feature in the great formation to which the sandstone belongs, and the peculiar petrographical circumstances of the rock in this locality, give some interest to the case as suggesting definite conditions to which the jointing is due. There is nothing new in the main cause thus educed, but so well-marked an instance of local action, or of secondary influences, may be worth recording.

The sandstone belongs to an upper member of a great series of rocks representing a well-defined period in the geology of India, beginning with the glacial deposits of the Talchír group, upon which rest the coal-measures, and ending with various groups hitherto included under the name Máhádévá. These strata, as a whole, are but partially indurated and only slightly disturbed. Jabalpúr stands upon a boundary of the formation running continuously for 350 miles in an east-30°-north direction, along the valleys of the Narbadá and the Són. In this neighbourhood the massive sandstones, irregularly associated with pale shaly clays, are even softer than usual, weathering with well rounded outcrops and an undulating surface. It is difficult at first sight to believe that the sharply edged, cliffed rocks of the Kattungá hillocks can belong to the same formation. Looked at from the north-north-west or the south-south-east they would be taken for well-bedded vertical quartzites.

In the annexed diagram (Fig. 1) a number (56) of observed bearings of the joint-planes are tabulated. Excluding only seven bearings, all in the north-east quadrant, the remainder

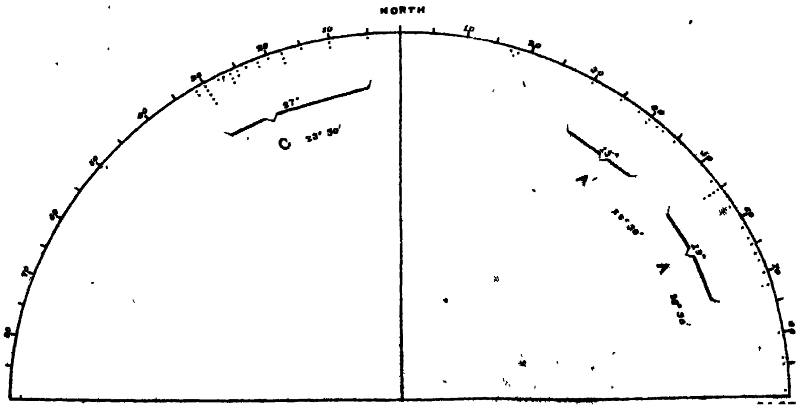

Fig. 1.—Diagram showing bearings of joints in the sandstone of Kattungá, Jabalpúr.

can be distributed into three groups. The numbers of observations in the two quadrants respectively do not at all represent the relative importance of the groups. The group C predominates greatly, dividing the whole rock-mass into cleanly separated vertical layers of from six inches to three and four feet in thickness. About an equal number of the cross-joints in the north-east quadrant were taken in order to obtain fair averages of their bearings among themselves. These cross-joints are much less regular than the main joints, often leaving unbroken spaces of thirty and forty feet: the planes, too, are less continuous, and frequently have a considerable underlie.

It will be seen from the table that the three groups present a very satisfactory illustration of Professor Haughton's explanation of joint-systems,* which assigns definite mechanical relations between the directions of the joint-planes traversing any mass of strata and those of the compressing forces that have affected them. The Primary system, generally the predominating one, following Sharpe's law of cleavage, occurs at right angles to the main compressing force. The second system is determined at right angles to the Primary, and therefore at right angles to the direction of least compression, from which relation to the Primary it is called the Conjugate system. Other four systems, (respectively conjugate to each other) may be determined, related to the two main systems by the limiting angle of friction of the rock. There is no difficulty, for the case under notice, in assigning the direction of the compressing forces by which the rocks have been affected, and thus obtaining the key to the induced rock-structure. Although, as a whole, these formations lie in their original position of deposition, there are many instances of even intense disturbance near the boundaries of the basin, where much of the compressing forces seems to have been expended, the yielding masses of the newer sedimentary deposits being here in contact with highly consolidated metamorphic rocks. The flexures of the strata thus produced observe a very general parallelism to these boundaries. As already mentioned, the boundary upon which Jabalpúr is situated has a very steady general bearing of about east-30°-north. In this immediate neighbourhood there is a single case of disturbance, and it conforms to the rule just indicated: at about half a mile to the south-east of the quarries there is a ridge formed of strata of the same formation dipping at 30° to south-35°-east. The direction of the compressing force being thus fixed, it is evident that the A group of joints, at right angles to that direction, represents very closely the Primary system; its mean bearing being 28°30′ north of east. The group C, which is here the dominant one, then takes its place as the Conjugate system to A. Its mean range in the diagram is 23° 30′ west of north, giving only 85° between it and A; but this might evidently be brought much nearer to the normal by slightly limiting the range of the group to where the readings are concentrated. The group A would come in as a Secondary system to A^1, the angle between them being 22° 30′. Interpreted from this point of view, it would seem that the direction of the main joints C was determined at right angles to that of least compression.

What it is chiefly desired to exhibit in this example is the conditions which seem to have produced so very local a peculiarity. It may, I think, be presumed that the power concerned was the shrinkage upon induration—a familiar agency in such phenomena; but it seems to have been seconded in an essential manner by local conditions, such as the texture, the homogeneity, the thickness, of these masses, or by their position upon a more rigid base. These determining secondary causes are, at least, suggested by the comparison of the Kattungá locality with others in the neighbourhood, where the induration is quite as great without similar jointing. Several such cases may be seen on the open ground to the east of the station, where there are a few scattered rocky hillocks, of about an acre in extent, formed of hard sandstone of the same age as the Kattungá rock, but without regular jointing.

* Phil. Trans. for 1858 and 1864.

The Kattungá sandstone is of moderately coarse texture. Although the stone is firm, the binding ingredient is in small proportion; there is a sprinkling of white clay, but not sufficient to fill the interstices of the grains; the stone thus remains a freestone, dressing well under the chisel. From a cursory examination made by Mr. Tween, the cement would seem to be a slight infusion of silica; it is unaffected by ordinary solvents. The stone of the other hills is somewhat finer in grain, with a full proportion of matrix, which, under the indurating action, assumes a porcellanic state. This highest induration seems confined to the parts along the few irregular joints that occur, but in the interior of the rough masses the stone is still quite as hard as that of Kattungá.

From top to base of the Kattungá hills there is no sign of bedding. The lamination is, however, betrayed by slight variations in texture, showing the original lie of the rock and its undisturbed horizontality. There is no such massive bedding in the sandstone of the other hills; even shaly partings are not unfrequent.

Such differences of texture, structure, and homogeneity might go far to explain the exceptional feature in the Kattungá rock; but there is a peculiarity in its position that is worthy of notice in this connection. The main area of the formation lies to the south-south-east; and in the low ground to the north of the quarries the soft sandstones and shales are again found in well-sections under the alluvium; but at a short distance to the west there is a range of granite-hills, on the continuation of which, prolongations and inliers of the granite weather out for some distance in the low ground close to the south of the quarry-hills. Thus it seems highly probable that the sandstone here is throughout underlaid almost immediately by the granite. At one spot this is fully seen, where a small promontory of sandstone crosses to the west of the city-branch of the Nágpúr road, and rests upon a knoll of granite. Directly coating the uneven surface of the granite there is here seen a variable bed of coarse arkose, now in a rusty and friable state; its surface is conglomeritic. Upon this rests a two-feet bed of a very peculiar rock—a coarse mixed sandstone with an excess of earthy matrix in a highly indurated, porcellanic, condition; the whole shivered into most irregular blocks. This same quartzite is very extensively found along the base of the formation as a contact-rock; but it also occurs near the boundary between soft earthy beds. In the section under notice it is immediately overlaid by a remnant, some fifteen feet thick, of the highly jointed sandstone. The hard but unjointed sandstone of the other localities rests upon a considerable thickness of the unconsolidated sedimentaries. May it not be that the shrinkage in the latter cases was satisfied to some extent by external yielding; whereas in the Kattungá rock it had all to be accounted for within the mass?

Although there is much reason to believe that the directions of these joint-systems were determined in accordance with the law expounded by Professor Haughton, it is necessary to suppose that even the Primary joints were here developed from a latent state by the same conditions that produced the main jointing, the compressing force not having been sufficient directly to complete this cleavage-jointing.

20th May, 1872. H. B. MEDLICOTT.

A FEW ADDITIONAL REMARKS ON THE AXIAL GROUP OF WESTERN PROME, *by* W. THEOBALD, ESQ., *Geological Survey of India.*

Since the publication of my remarks on the axial group of Western Prome, in the Records of the Geological Survey, No. 2, 1871, the more extended examination of the neighbouring country has made it necessary to restrict the group within somewhat narrower limits than I had at first assigned to it; and I think I shall best convey an idea of the extent and scope of such limitation by briefly sketching the various steps by which our knowledge of these beds has been acquired.

In 1861, Mr. W. T. Blanford, who was then entrusted with the survey of Pegu, expressed an opinion, founded on the examination of the Bassein district, that the altered, or "Hill rocks" as he termed them from their being confined to the hilly region wherein the Arakan range here becomes merged, were as likely as not altered Nummulitic strata, notwithstanding the gene al difference in character between these "Hill-rocks" and the unaltered Nummulitics met with in the plains and outer hills; though this view could not be corroborated by fossil evidence, as no fossils had then been detected in these "Hill-rocks."

A few years later I visited a portion of the ground surveyed by Mr. Blanford; the result being that I found myself unable cordially to assent to the above view of Mr. Blanford, and preferred to allow the point to remain an open one in the hope of some evidence of a more positive kind regarding the relation of the altered and unaltered rocks of Pegu being forthcoming in time elsewhere. About this time, my colleague, Mr. F. Fedden, who was then working with me in Pegu, discovered some dark shales containing Foraminifera, (*Operculina*) in a small stream, on the western side of the Arakan range, falling into the Gwa river, and this, with one more recently discovered, which I shall notice presently, is the only instance with which I am acquainted of fossils having been detected well within the area of the "Hill-rocks."* The isolated occurrence, however, of a few fossils, even the most characteristic, at a single spot would not have been conclusive as regarded the age of the group constituting the great mass of the Arakan hills; and little or no progress was therefore made towards the solution of the question of identity or not of the altered and unaltered rocks of the Arakan range up to the time of my writing my remarks on the axial group in the Records of 1871. When, therefore, I commenced work on the frontier in the season of 1869-70 among the "Axials" as restricted by me, which are here so well displayed, and in such contrast to the Nummulitic group of the plains, I recognised, as I thought, a confirmation of the view to which I had always inclined—namely, the distinctness, geologically speaking, of the altered and unaltered rocks which had proved so puzzling in Bassein—and in commencing to follow up south the boundary of the Axial group and the Nummulitics, I not unreasonably supposed that I was holding the clue to the true relations of the rocks in Bassein. At first of course all went satisfactorily enough, the nature of the ground considered, for I was dealing with a veritable geological boundary; but I had not got well out of the Prome district when I began to feel less satisfied with my work. It may be remembered that I described the upper or typical Axials as resting on a series of shales and sandstones which possessed much of the general aspect of the Hill-rocks met with to the south; and I somewhat hastily, though with a great show of probability, concluded that they belonged to the same group, and that the fault, which, as I believed, brought in the upper Axials against the nummulitic strata in Prome, continued on and brought up the lower Axials in like manner to the south. By the time, however, I had reached the confines of the Bassein district, I became convinced that the boundary I was then following was illusory, that is, not a geological one, but merely one dividing the altered from the unaltered side of the same group, and which was becoming more and more vague towards the south, where, as Mr. Blanford had originally remarked, no separation was possible between these often dissimilar but really geologically identical groups. Although I am now convinced in my own mind of the correctness of the view originally put forward by Mr. Blanford, I deemed it highly desirable, if possible, to procure some corroborative evidence. I had, it is true, failed to detect any fossils in any limestone I had yet examined within the area of the Hill-rocks; and this, coupled with the fact of nummulites being plentiful in many places among the unaltered beds, had much tended to strengthen my doubts of the view I was at length forced to adopt, but I determined to visit one spot where Mr. Blanford has marked limestone on the Pyennea Choung, ten miles west

* The Ranmi limestone contains corals and other fossils, but in a state that renders it doubtful if they can be satisfactorily made out.

of the Bassein river, within the area of the Hill-rocks. At first this limestone seemed as devoid of fossils as most of the similar outcrops of the rock within the hills examined by me, but in one place I was rewarded by finding numerous small nummulites in it, which seemed to have escaped the molecular action, which, I presume, is the true cause for the general disappearance of fossils in the rock, and not its originally azoic character. Having thus satisfied myself that the "Hill-rocks" of Blanford comprising the southern portion of the Arakan range were of Nummulitic age, and consequently distinct from the Axials of the Prome district, it became necessary to retrace my steps in order to discover where, in following down the line of altered rocks, I had, as it were, got shunted off the Axials on to the Nummulitics. This point was very soon ascertained. The upper Axials, which are so well displayed on the frontier, hold their course continuously to within a short distance of the Thanni Choung, a distance of forty-seven miles as the crow flies, from where they enter British territory, or a little above the parallel of Prome. A few rolled lumps of the characteristic grits of the upper Axials may be seen in the Thanni Choung, below the junction of a small stream, (the Thaybew Choung, not on map); but nowhere else can any evidence of the presence of this group be detected in the Thanni Choung, either above or below this spot. The upper Axials indeed stop here abruptly; for, a very short distance up the Thaybew Choung the characteristic axial limestone comes in, from which I obtained numerous specimens of an echinoderm, unfortunately none of them in a state for identification. Thus far the boundary of the group is, I believe, a faulted one, but here the fault would seem to die out and the group to be covered up by the altered Hill-rocks of Nummulitic age. The rocks actually seen in the Thanni Choung do not give much assistance towards determining the question of their age. Just below the junction of the Thaybew Choung the shales are seen which may confidently be referred to the Nummulitic group. Above the junction of the Thaybew Choung great disturbance and alteration of the beds is seen; harsh indurated sandstones, vertical and much shattered and disturbed, occur, and above this spot, sandstones and shales of the ordinary kind met with among the Hill-rocks. Now, for any direct evidence to the contrary, these might belong to either group; and their position is quite such as would identify them with the group of similar character underlying the upper or typical Axials. Thirty miles south of this is the village of Chin-na-gyee, where, in my note on the Axials, I thus described the boundary which I then supposed was the junction of the two groups, and the continuation of that which in reality stops short of, and without crossing, the Thanni Choung. "The stream above Chin-na-gyee seems to display mostly shales of the lower group, and just south of the village in the bed of the stream, highly altered sandstones come in of the usual harsh character of so many beds belonging to this portion of the group. Not thirty yards below them comes in, quite unaltered, a calcareous sandstone profusely charged with nummulites. The *boundary* is here fixed within a few yards, and strikes through the centre of Chin-na-gyee village, and at this point would seem to completely cut out the whole upper group" (of Axials). This section is merely a better and more sharply defined one than usual of the ordinary junction of the altered or Hill-rocks with the unaltered Nummulitics; and at the time I first visited it, I had no doubt of its being the faulted boundary of the two groups (Axials and Nummulitics), instead of merely the boundary of that peculiar metamorphism which characterises the Hill-rocks, and which, the further we go south, seems more and more capriciously and irregularly developed. Of the lower Axials, now that all the Hill-rocks to the south are separated from them, we know very little. The country occupied by them being, without any figure of speech, most impracticable. From the point near the Thanni Choung, where the group terminates, the boundary recedes to the westward along the watershed separating the Thanni Choung from the Muday Choung to the north. This is indicated in the map by a dividing range, which gives a very inaccurate conception of the physical aspect of the country, though it may, very probably, correctly enough mark the actual watershed. Nattoung, a conical hill capped with serpentine, is situated between the Thanni and Muday streams, at almost the extremity of the axial area. It is steeply scarped on three sides, but is accessible on the north-north-east by a steep spur. From the summit a fine view is obtained of the ground intervening between it and the main Yomah range, but which being intersected by no considerable stream, totally uninhabited and covered with virgin forest, is quite impossible to explore; and it is not till the western side of the Arakan range and the Akyab district comes under survey that more details of the Axial group can be looked for; and even then the difficulties presented by the wild, forest-clad and uninhabited nature of the country in question will for many years act as a complete bar to anything like a full and satisfactory examination of the ground. It is beyond the aim of my present note to enter on the relations, as far as known, of the Axial group to the westward, and I will content myself with a brief recapitulation of the main points now established.

1st.—The Axial group extends down into Pegu, a distance of about forty-seven miles from the frontier; the boundary on the eastern or Pegu side of the Arakan range being a faulted one, having a strong upthrow to the west, whereby the upper Axials are brought into contact with the Nummulitic group.

2nd.—There is no evidence that any portion of this group passes south of the Thanni Choung, though the precise boundary between the lower Axials and the "Hill-rocks" or altered Nummulitics is obscure and at present only provisionally determined.

3rd.—On the western side of the range, a great thickness of beds intervenes between the Axial group and the Nummulitics, amongst which the presence of cretaceous rocks is shown by the occurrence of *Ammonites rostratus*, Sow., near Maie. These cretaceous strata certainly extend as far south as Kaintali, but being in the province of Arakan, have only received a very cursory examination.

May, 1872.

SKETCH OF THE GEOLOGY OF THE BOMBAY PRESIDENCY, *by* WILLIAM T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The Bombay Presidency consists geologically, as well as physically, of two parts. The north-western of these consists of Sind, Kachh and Gújrát; the south-western comprises the Marátha country. Roughly the river Narbadá (Nerbudda) may be said to divide the two regions. A part of the distinction is climatic, the north-eastern division being, to a great extent, beyond the area of the periodical monsoon rains, but the essential differences are due to the very dissimilar geological formations of which the two regions consist.

The geology of the Marátha country is for the most part of the simplest kind, by far the greater portion of the surface being composed of nearly horizontal strata of basalt and similar rocks. Hence the peculiar features of the country, the extensive plateaus, the long hog-backed hills, the terraces on their sides, and the black precipices which in so many places almost cut off communication with the low ground. Hence also the fertility of the soil which covers the country, and its adaptation to the growth of cereals, pulse, and cotton; and to the same cause may be attributed the thinness and stunted growth of the forests except in a few favoured localities.

The rocks of the Bombay-Deccan are precisely similar to those of neighbouring portions of the Indian peninsula.* India proper in its geology stands as strikingly aloof from neighbouring portions of Asia as it does in its ethnology and zoology. But the rocks of Gújrát, Kachh and Sind, are only partially represented in the Indian peninsula, and must rather be considered as

* By India I mean the country of the Hindu races. To call Burma, the Malay peninsula, Siam and Cochin China, and, still worse, Java, Sumatra, and Borneo, India appears to me a scientific blunder. The countries have no geographical, geological, ethnological, nor zoological connection with India proper.

belonging to Continental Asia, being continuous, as was long since shown by Dr. Carter, with the formations found in Persia and Arabia. To the northward the Sind rocks extend to the foot of the Himálayas.

To this striking change in the geology is due to no small extent the difference in the physical features of the countries north-west of Gújrát. Instead of plateaus covered by black soil, we find undulating sandy plains with scattered craggy hills; the immense alluvial flats to the north of Kachh and Gújrát are for the most part deserts of blown sand, and the fertile country consists of a belt, rapidly diminishing in breadth to the westward, along the borders of the sea; its verdure is due to the humidity caused by the neighbouring ocean. In Sind even this ceases, and the country, except on the banks of the Indus, or where reclaimed by irrigation, is an arid tract of gravel and sand from which arise the steep scarps of limestone ranges.

In the ensuing brief description of the different groups of rocks found in the Bombay Presidency, it will be seen that each system is mainly developed in one or the other of these two great divisions. The only important exception is in the metamorphic rocks at the base of the whole geological series. The basaltic traps extend into Káttiáwár and Kachh, but they occupy but a small area. The division of course is not absolute, but it is evident that, as has been suggested by Professor Huxley, the Indian peninsula has had, during the later geological epochs, a different history from the country to the north-west. In the following list of formations the Indian classification has been adopted, partly in order to show the relations of the various beds of Sind and Kachh to those of the Indian peninsula, partly because the usual European classification is quite inapplicable to the latter; for it is as yet a moot point whether the great Deccan trappean series is secondary or tertiary, and the European equivalents of the Vindhyan series are unknown with any accuracy.

The following is a list of the formations found in the Bombay Presidency and its dependencies in descending order :—

VI.—Later tertiary and recent ...	1.	Black soil.
	2.	Littoral concrete.
	3.	Alluvium of Sind, Kachh, and Gújrát.
	4.	Laterite of the Konkan.
	5.	Surface gravels of Sind.
	6.	Ossiferous gravels of river valleys.
	7.	Upper tertiaries of Káttiáwár and Kachh.
V.—Older tertiary or nummulitic series.	1.	Older tertiaries of Súrat, Bharoch, Káttiáwár, Kachh, and Sind.
	2.	Perim Island bone beds.
	3.	Laterite of the Deccan.
IV.—Deccan series ...	1.	Deccan traps.
	2.	Intertrappean beds of Bombay.
	3.	Ditto of Dewad, Nágpúr, Narbadá valley, &c.
	4.	Cretaceous beds of Bágh.
III.—Oolitic series ...	1.	Jurassic rocks of Kachh: upper.
	2.	Ditto ditto : lower.
II.—Vindhyan series ...	1.	"Diamond limestone" and sandstone of Belgáon, Kaladghi, and Ratnagiri.
I.—Submetámorphic and metamorphic.	1.	Champanír beds.
	2.	Granite, gneiss, mica schist, &c.

These are all which are actually known to occur in the area to which the present notice relates and its immediate vicinity; but in order to explain them, it will be needful occasionally to make brief reference to strata found in adjoining districts. In proceeding to give a brief description of these various formations and of their distribution in the Bombay Presidency, I shall, as is customary and most convenient, commence with the oldest.

I.—METAMORPHIC AND SUBMETAMORPHIC SERIES.

1. *Metamorphic rocks.*—Under this heading are classed together all the crystalline formations, *granite, syenite, diorite, &c., gneiss, hornblende-schist, mica-schist, quartzite, crystalline limestone, &c.*, whether laminated or not. It is possible that veins of granite, syenite, and diorite may exist of later date than the metamorphism of the gneiss, but none have been met with as yet of which the later origin can be proved; and the majority of such veins are clearly contemporaneous with the metamorphic action, whilst throughout India wherever extensive areas of granite have been examined with care, the rock has been found to pass gradually into gneiss or schist on its edges, or here and there throughout the tract of country composed of it. The only exceptions to the rule of the apparent contemporaneity of the granite and gneiss are in the granitic masses found associated with submetamorphic rocks in places. But the relations of these submetamorphic rocks themselves to the gneiss and its associates are far from clear.

Veins and irregular masses of greenstone (diorite) are similarly found passing into hornblendic gneiss. There are, however, in places trap dykes of later age contemporaneous with the Deccan traps or other outbursts; but many of the dykes which intersect the crystalline rocks are evidently of very old date, because they do not penetrate the superjacent strata.

It is quite possible that several series of rocks of widely differing ages are included in the metamorphic formations of India, and Mr. H. B. Medlicott has pointed out some facts in favor of such a division amongst the crystalline rocks of Bengal.* But until these have been traced out more completely than has hitherto been practicable, it is necessary to class all together.

Metamorphic rocks cover a much smaller area in the Bombay Presidency than they do in most other parts of India. None are known to occur in Sind or Kachh, but north of the Ran of Kachh, they are seen at Nagar Parkar, and thence stretch to the eastward towards mount Abú, which is composed of them. They occupy a large tract in northern Káttiáwár, including Girnár hill, which is their southern limit; they are also found close to Palitána and in the neighbourhood of Gogo, but the detailed geology of this country and of the regions to the north is very imperfectly known. East of the great alluvial flat which extends northward from the Gulf of Khambayát (Cambay) metamorphic rocks of a highly granitic character occupy the country about Idar, and occur throughout a considerable tract around Godoa and Chota Udepúr in the Rewa Kanta, but they are covered up by sandstone and trap to the south, and nowhere in this direction reach the river Narbadá, whilst east of Baroda, near Champanír, they are replaced by the other rocks to be presently described.

From the Narbadá to the southward metamorphic formations are unknown† within the limits of the Bombay Presidency until the southernmost districts are reached, in which they again appear, and they occupy nearly the whole western portion of the Indian peninsula from this limit to Cape Comorin. On the coast they emerge from beneath the higher formations just north of Málwán, and nearly the whole of Sawantwadi, the Goa territory, and North Kanara is composed of them, their surface being frequently concealed by thick deposits of laterite. In the high table-land east of the ghâts, the southern part of Belgáon, the south-eastern corner of Kaladghi, and nearly the whole of Dhárwár consists of these formations.

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* Records, Geological Survey of India, Vol. II, p. 40.

† In Greenough's geological map of India granite is represented as occurring in three places in the trap area of the Deccan. These places are close to Elúra (Aurangabad), Satara, and Kolhápúr respectively. It appears doubtful whether these granitic inliers really exist. There is one small patch close to Phonda in the Konkan, twenty-five miles south-west of Kolhápur, but this is far from the position indicated by Greenough.

SUBMETAMORPHICS—CHAMPANÍR BEDS.

The classification of such Indian rocks as are distinguished from the gneiss and its associated formations by partial or total absence of metamorphism, and yet are of greater age than the Vindhyan series, is extremely imperfect. It is uncertain how far the various local groups represent each other, and to what extent any or all of them are the less altered of the true metamorphic rocks.

The only known occurrence of these submetamorphic rocks within the Bombay area is near the ruined town of Champanír at the foot of Pawágarh hill, east of Baroda. These beds occupy an area stretching for about twenty miles east from the hill (which is of trap) and for a considerable but unknown distance to the north. The principal constituent formations are quartzites or rocks intermediate between quartzite and sandstone conglomerates: slates and limestones also occur in considerable quantities, and ferruginous bands, some of them chiefly consisting of magnetic iron ore, occasionally. The limestone is sometimes quite unaltered, but in places it is highly crystalline, and at one spot near the village of Kadwal, it contains fine crystals of actinolite. The most characteristic beds are perhaps the conglomerates, the matrix of which is a coarse sandstone, containing pebbles and rounded blocks of granite, quartzite, talcose slate and crystalline limestone, some of which, especially those of limestone, have a diameter of a foot or more. All the finer argillaceous beds exhibit cleavage, and some of the slate is so fissile that it might probably be employed for roofing purposes. On their southern boundary these beds appear to pass by gradual transition into the true metamorphics.

The relations of the Champanír group, as these beds have been provisionally named, to the other submetamorphic beds, remain hitherto somewhat obscure, but they are perhaps the representatives of the Gwalior series (see Records, Geological Survey of India, Vol. III, p. 33). From the Bijáwar rocks of Bandélkhand and the Narbadá valley they differ much in mineral character.

II.—VINDHYAN SERIES.

The rocks to which the general term Vindhyan has been applied from their extensive development in the Vindhyan plateau north of the Narbadá consist of sandstones (occasionally so hard as to assume a semi-vitreous appearance and to approach quartzite in character), limestones and shales, and are very often distinguished by a more or less pink or purplish colour, less frequently seen in the limestones than in the other rocks of the series. These beds are separated by a well-marked geological break, the evidence of which is found in extensive unconformity, from all the earlier formations. They are divided into two principal groups, an upper and lower one, the former of which, comprising the typical Tárá sandstone, Kattrá shales, and Panná sandstone of Dr. Carter, and the Bhánrer, Rewá, and Kaimur groups of the Geological Survey classification, occupies an immense tract in Málwá and Bandélkhand, whilst the latter is only found here and there upon its borders. Very large areas in the Máhánadi, Godávari, Krishná, and Pennér vallies are occupied by sandstones and sandstone-quartzites, limestones and shales closely resembling the Bandélkhand rocks in mineral character, but more nearly allied to the lower than to the upper sub-division. They are identical with the diamond-sandstone and limestone of the earlier Indian geologists,* and were included by Dr. Carter in his Oolitic series, together with the important formations hereafter to be mentioned. Unfortunately, no well authenticated fossil, animal or vegetable, has hitherto been obtained from these beds, the few supposed organic remains which have been recorded as occurring in them being either of a very doubtful nature or else derived from strata of later date. The geological age of the

* The diamond sandstone, however, as described by Voysey and Malcolmson, comprised formations which have now been ascertained to belong to a series of much more recent date than the Vindhyans.

Vindhyans is therefore obscure, all that can be safely asserted being that they cannot be more recent than the middle palæozoic rocks of Europe, whilst they may be considerably more ancient.

The Bandélkhand Vindhyan area is entirely outside of the Bombay Presidency, its south-western corner being at Barwai in the Narbadá valley, but the representatives of the same series in the Krishná valley and its vicinity occupy a well marked belt, locally of considerable width in the southern part of the Presidency, intervening between the trap and the metamorphic rocks. These beds appear on the west coast at Ochrá, a little north of Málwán. They are well seen at the foot of the Phonda ghât, and consist of hardened sandstone approaching quartzite, white, yellow, or pink in colour, and shales. The surface is very uneven, and had evidently suffered greatly from denudation of an irregular kind before it was covered by trap; hence their distribution at the base of the volcanic series is very irregular.

Above the ghâts the quartzites reappear in the south of the Kolápúr territory, and extend eastwards in a band of very variable width across the southern parts of the Belgáon and Kaladghi districts into the Nizam's dominions.

On its northern side this belt of country is bounded in most parts by the extremely ragged southern edge of the Deccan trap-area. To the south it is bounded for some distance by the trap, but after that by the northern edge of the great gneiss-area of Madras. A little east of where these rocks cross the Krishná river, thirty miles east-north-east of Kaladghi, the continuity of the belt is broken for a short distance; but another series of quartzites, shales, and limestones is met with at Múdebehál, and stretches away to the north-east into the Nizam's territory to the neighbourhood of Gúlbargá.

In the central part of the area around Kaladghi the quartzites are overlaid by a great thickness of limestones and shales; above these, again, comes a considerable quartzite series, which in its turn is overlaid by another set of limestones and shales. These different limestones, &c., occupy a considerable area in the valley of the Gatparbá, both east and west of Kaladghi. The limestones are generally subcrystalline and of various degrees of purity; they are often highly silicious, and many beds are very argillaceous—indeed often pass into calcareous shale.

The lower quartzites are considerably tilted along the greater part of the southern boundary and form a fringing ridge, with an abrupt scarp, overlooking the gneiss area.

The basement beds of the lower quartzite series contain many very remarkable conglomerate beds; the included pebbles being of banded jasper, quartz and felspar, derived from the gneissic series.

Some few beds of jaspery hæmatite-schist occur in the lower quartzite series in Balgi ridge north of Kaladghi.

Where the beds are lying quite undisturbed and horizontal they have not assumed the character of quartzites, but are true sandstones, but, wherever disturbed, the metamorphosing effect of pressure has changed them into more or less perfect quartzites. Two of the most beautiful and interesting scenes in Western India—the falls of the Gatparbá at Gokák and the "Naul Tirth" (the peacock's bath) in the gorge of the Malparbá river near Manóli—are due to the peculiar position of the lower part of the quartzites.

The series of quartzites which lies near Múdebehál eastward of the break above referred to differs from the Kaladghi series in several important points; the former consists of a thin basement-bed of pebbly sandstone overlaid by shaly sandstones, and these again capped by limestones; the whole, as far as seen near Múdebehál and Tálikót, not exceeding 200 feet in thickness. The Kaladghi beds are of far greater thickness; the basement quartzites and conglomerates alone being many hundred feet thick; over which comes a great thickness of brecciated quartzite followed by the two great limestone and shale series above described and the upper quartzites which divide them.

The limestones also differ in character, those occurring at and around Tálikót being fine-grained lithographic limestones with few inclusions of chert, while those at Kaladghi are subcrystalline and full of chert both in laminæ and in irregular nodular masses.

From the differences above enumerated, it appears reasonable to conclude that the Múdebehál and Tálikót beds are not continuations of those around Kaladghi, but members of another, and from its lesser degree of metamorphism in all probability a younger system of rocks. This conclusion is strengthened by the fact that the quartzitic groups in the Madras Presidency are referable to two series—the lower or Kadapá series, probably representing the Gwalior series of Upper India, and the upper or Karnúl series, representing the Lower Vindhyans. For convenience of description, the name of the town Kaladghi has been given to the series of beds occupying so large an area of the Gatparbá valley, and that of the Bhímá series to the Múdebehál and Tálikót beds, as they are far more extensively developed in the valley of the Bhímá river. The beds at the base of Phondá ghât belong to the Kaladghi group.

Above the Vindhyans there is found in Central India and Bengal a most important series of formations, to a portion of which the only coal beds worked on the Indian Peninsula belong. The various groups, including the Talchír, Damúda, Panchet, Máhádévá, &c., are largely developed in the Central Provinces; but all disappear below the traps far to the east of the Bombay Presidency, and none of them have hitherto been detected along the southern edge of the trap area in Belgáon, Dhárwár, and Ratnagirí.

The absence throughout the Bombay Presidency of the coal-bearing Damúda groups, so widely spread in the Central Provinces and South-Western Bengal, is a serious drawback to the commercial prosperity of the country, and, coupled with the rapidly progressing destruction of the forests, threatens to leave a large portion of that Presidency as destitute of fuel as the Panjáb and parts of Madras. There appears to be but little hope of the discovery of useful coal in Western India in any large quantity.

III.—Oolitic Series.

The rocks of Kachh, first described by Captain Grant, have lately been examined by the Geological Survey. The formations below the trap occupy the northern half of the province and the hilly parts of the island in the Ran, and consist of two groups, the lower of which is distinguished by a prevalence of argillaceous beds, with which sandstones and limestones are intercalated, the upper group is marked by a predominance of coarse sandstone.

The shales of the lower group vary in colour and consistency, and they sometimes contain gypsum. Ferruginous bands are less common than they are in the upper beds. Locally, fossil shells, always of marine forms, are common in these rocks.

The sandstones of the upper group are white and felspathic, except towards the base, where they are brown in colour, and abound in ferruginous bands and nodules. Throughout the whole, but far more sparingly than in the lower group, shales are scattered, containing plant remains, often fragmentary and undefined, but, when recognizable, consisting chiefly of cycads and ferns. Some of the shales are carbonaceous, and in a few localities, as at Trombo north of Bhúj, thin seams of coal have been met with, but none hitherto discovered have been sufficiently thick to repay extraction.

These two groups, although contrasting in some respects, have much in common, most of the beds in each being similar to some in the other; nor can any absolute line of separation be drawn between them. As a rule, the marine fossils are peculiar to the lower and the plants to the upper group; but exceptions occur, and interstratifications of shale containing plants have been found between beds rich in marine fossils near Chari in the lower group; whilst, in the western part of Kachh, bands with marine fossils are intercalated in the upper. It is evident, therefore, that both form a continuous series without any important break, and that they are not of different geological epochs. The age is shown by the numerous marine fossils comprising many species of *Ammonites, Belemnites, Pleurotomaria, Astarte, Avicula, Gervillia, Lima, Nucula, Opis, Ostrea, Pholadomya, Plicatula, Trigonia, Rhynchonella, Terebratula, &c.*, to be of middle and upper jurassic age, some of the species being identical with those common in the same groups of Europe. The plant-fossils, on the other hand—including three species of *Palæozamia*, some conifers, resembling *Brachyphyllum, Taxodites* and *Walchia*, a *Tæniopteris*, and a *Sphenopteris*—are for the most part identical with those found in the beds intercalated with the lowest beds of trap in the Rájmahál hills of Bengal, and in some clays occurring beneath the cretaceous beds of the neighbourhood of Trichinopoly and at Sríparmatúr near Madras.

The whole thickness of the jurassic beds of Kachh, so far as they are seen, has been estimated by Mr. Wynne at 6,300 feet, of which 3,000 may be allowed for the upper group; but it should be borne in mind that this does not give the whole original vertical extent of the series, since their base is nowhere seen, and their upper surface had undergone denudation before being covered up by the trap.

It is not known that the Oolitic formations occur in the Bombay Presidency and its dependencies beyond the limits of Kachh. Some representatives of them may perhaps be found in northern Káttiáwár or in the neighbourhood of Dísa, but none appear as yet to have been made known. Dr. Impey near Jaisalmir (Jeysulmeer) found, in a well, some ammonites which Dr. Carter thought might be of jurassic age, but in fact the geology of Western Rájputáná and of the countries lying north of Kachh is very little known.

IV.—DECCAN SERIES.

Lametá and Bágh beds.—The next great series in ascending order is far more important in Western India than any of those inferior to it in position, and it covers as large an area in the Bombay Presidency and its dependencies as all other formations together. The greater portion is of volcanic origin, consisting of stratified basaltic or earthy traps, but at the base of the igneous rocks, there is in the Narbadá valley, a very interesting group of sedimentary beds, which, from their geological relations, must be classed in the same series. These are the cretaceous strata of Bágh, Chota Udepúr, and Rájpipla.

In many places to the eastward, there is found at the base of the traps a bed of impure, earthy or gritty limestone, frequently containing pebbles, and passing occasionally into a sandstone or conglomerate. It has been traced throughout a considerable portion of the Narbadá valley and the country around Nagpúr. To this formation the name of Lametá was given by Mr. J. G. Medlicott from its occurrence at Lametá ghât on the Narbadá near Jabalpúr, and it was at one time supposed to represent, in part, the massive sandstones of the Máhádeo hills around Pachmari. This has now been disproved, but it appears highly probable that the Lametá bed is the equivalent of the limestones and sandstones of Bágh.

Wherever this infra-trappean formation occurs, its close connection with the overlying traps is manifest. The Lametá group is apparently of fresh water origin, having in all likelihood been deposited in lakes formed by the damming up of vallies by the first flows of lava, and it is therefore similar in its mode of deposition to the inter-trappean beds to be presently noticed. Fossils are but rarely found in it; the few that have been obtained are fresh-water shells, reptilian bones (?) and wood. But although it is evidently of different origin from the Bágh group, its similarity in mineral character to the uppermost bed of the latter is most striking, and there is also great resemblance in the conformity of both Lametá and Bágh beds to the overlying trap, although this character is less striking in the Bágh beds in consequence of local unconformity.

Numerous small patches of infra-trappean rocks occur along the southern boundary of the Deccan trap in Belgáon and Kaladghi districts. They rest either on the Vindhyan or the gneissic rocks, and are invariably of small thickness, rarely exceeding 6 or 8 feet, and generally of even much less thickness. The beds consist generally of soft sandstones or marly sand with numerous quartzite and a few gneissic pebbles. The top of the beds just below the trap is most frequently stained of a rich red from the presence of red bole. In the only case, near Kaladghi, in which fossils were found in these infra-trappean beds, they were of fresh water types—*Physa*, *Lymnea*, and *Unio*. It is still uncertain whether these are true representatives of the Lametá group, or only local overlaps of the inter-trappeans.

The Bágh beds consist of limestone or calcareous shales and sandstone, the former being almost always above the latter. The 'coralline limestone,' which first attracted attention to them from the blocks in the ruined buildings of Mándú near Mohu (Mhow), is a red or yellow rock mainly composed of fragments of marine shells and *bryozoa*. The source of the blocks at Mándú was long unknown, but was in 1856 traced by Colonel (then Captain) Keatinge to Cherákhán, about twenty-five miles east of Bágh. This peculiar rock forms the highest bed of the group over a small area east of Bágh, but it is not seen near that town, and is only very imperfectly represented to the westward.

At Bágh itself, 20 or 30 feet of nodular limestone rests on 80 or 100 feet of sandstone, which is in places conglomeratic and sometimes argillaceous or shaly. To the west in Alirájpúr and Chota Udepúr, the mass of the cretaceous rocks consists of coarse sandstones and conglomerates, capped by gritty limestone or calcareous shales. In the Deva valley near Dúmkhal in the northern part of the Rájpipla hills, a section of 500 feet of these calcareous shales is seen resting upon an even greater thickness of sandstones, but to the north the group becomes of much smaller dimensions; like the Lametás, the uppermost beds frequently abound in chert.

The traps in general rest conformably upon the Bágh beds, but there is much local unconformity, showing that the latter had in places undergone considerable denudation before they were covered by the volcanic rocks. From the nature of this denudation there can be but little doubt that it was subaërial, and that the marine beds of Bágh had been raised above the sea and subjected to the action of rain and streams before their surface was encased in the overflowing trap.

The fossils found near Bágh are unmistakeably cretaceous; and Dr. Martin Duncan has shown that the Echinoderms found at Cherákhán are mostly identical with species found in the Upper Greensand (Cenomanien) of Europe. A few specimens are met with farther west, but less abundantly. The most common to the west are species of *Ostrea*, but teeth of Sharks, *Pecten 4-costatus*, and *Hemiaster*, also occur occasionally.

In the lower Narbadá valley the cretaceous beds fringe the trap, and are occasionally exposed within the area of the volcanic rocks. The principal inliers to the westwards in the Rewa Kanta are near the town of Kawát, and a large one exists in the Deva valley in Rájpipla south of the Narbadá; whilst on the edge of the traps, a tract covered by these beds, fourteen miles long from north to south by ten miles broad, is met with a few miles south-east of Baroda near the villages of Wasná, Talakwárá, and Gandeshwar.

Stratified traps.—These rocks have engaged the attention of nearly all the geologists who have written upon Western India. Their thickness, peculiar appearance, and extent render them the most conspicuous geological feature of the country.

Lithologically the trap rocks consist principally of various kinds of dolerite, rich in augite, the prevailing forms being compact basalt, anamesite, and more or less earthy amygdaloid. Two of the most characteristic rocks are a porphyritic basalt containing tabular crystals of glassy felspar, and an amygdaloidal earthy trap abounding in small nodules of agate and zeolite surrounded by green-earth; the latter of these is exceedingly abundant. Some of the amygdaloids contain great quantities of zeolites and allied minerals; of these the most abundant are *Apophyllite, Stilbite, Heulandite, Scolecite,* and *Laumonite.* Besides these *Chabasite, Hypostilbite,* and *Thomsonite* occur, but they are rare, and I have once seen *Prehnite.* The *Apophyllite* is finer than at any other known locality, and of various colours, white, green, and pink. A great variety of agates and of other forms of silica, such as bloodstone, are also met with filling cavities or forming small veins in the rock.

The traps of the trachytic group in which felspar predominates, and which may be recognised by their pale color, are much less common, and are in fact only met with in a few localities, as at Dharavi in Bombay Island, Powagarh hill, east of Baroda, &c. They are usually ashy or earthy, but sometimes crystalline.

The whole series of Deccan traps is regularly stratified in beds, or, to speak more correctly, flows, varying from 5 or 6 feet to upwards of 200 in thickness. The average in two roughly measured sections on the railway-inclines of the Tol (Thull) and Bhór ghâts is apparently 87 and 64 feet respectively, but really less, because the distinction between any two beds can, in general, only be made out by mineral characters, and if, as frequently happens, two successive strata present no lithological differences, they are liable to be classed together as one. Many apparently massive strata of amygdaloid really consist of a number of separate flows from 6 to 10 feet thick, and it is doubtful if the average thickness of the strata exceed 20 to 30 feet.

A remarkable horizontality prevails throughout the greater portion of the trap area, the most important exceptions being in the Rajpipla hills, and the ranges immediately north of the Narbadá, in parts of the Satpúra hills north of Khandesh, and along the coast from some distance south of Bombay to Damán. In these exceptional areas the dips are clearly due to disturbance subsequent in date to the consolidation of the rocks, for sedimentary beds, which must originally have been horizontal, have shared in the movement. It is thus clear that throughout the area the traps must have originally been very nearly level.

Yet there can be no question but that these rocks are of volcanic origin. In many places beds of breccia are interstratified, which must originally have consisted of volcanic ash. Some are met with on the northern part of the Bombay Island, at Sion hill, Palshachi hill, Flagstaff, and Rai hills, and more in Salsette, the caves of Kanharí being excavated in one of them. Several beds are cut through on the Kamatké ghât on the road from Púnah to Mahableshwar, and a very conspicuous instance may be seen at the lower gateway of the hill fort of Singurh near Púnah. Indeed with a little search similar beds may be found almost anywhere in the trap country. When weathered, the resemblance of these breccias, with their enclosed scoriaceous blocks, to the ash beds of old volcanic cones is so exact that no doubt can remain as to their being of identical origin. The red bole which so frequently occurs interstratified with the traps may also be an ash, as it is intermixed with scoriæ in places, but it sometimes bears the appearance of having been rearranged by water. It should not be forgotten that the blocks which were originally vesicular or scoriaceous are now amygdaloidal, the hollows in them having been filled by infiltration.

But whilst the volcanic origin of the Deccan traps is unquestionable, their horizontality and regularity of stratification render them very unlike the accumulations of volcanic rocks now forming in countries in which igneous vents exist, and it is clear that the circumstances under which the former were accumulated were widely different from anything now known to occur on the earth's surface. Another remarkable distinction is the apparent absence, throughout a great part of the area, of any foci from which currents of lava could have been poured out. Of course cones of loose scoriæ would long since have been removed by denudation, and nuclei of solid basalt would not easily be recognised amongst flows of similar constitution. Still it is remarkable that so few instances should have been described. Unmistakeable nuclei exist in the lower Narbadá valley, some of them, as Metápenai hill south-west of Chota Udepúr, consisting of trachyte; and throughout a large tract in the Rajpipla hills the rocks are cut up by immense dykes; but still better examples of volcanic foci may be seen in Kachh amongst the jurassic rocks, one of them being the so-called volcano of Dinodar,* west of Bhúj. Mr. Clark also (Quart. Journ. Geol. Soc., 1869, p. 163,) states that a line of vents exists in the Konkan east of Bombay, and that large numbers of dykes occur; but whilst it is highly probable that there are volcanic foci in this direction, it is doubtful if any large portion of the Deccan traps have flowed from them, for the frequent occurrence (locally, it is true, not universally) of trap dykes, and still more of ash-breccia appears to show that centres of eruption must have been scattered widely over the country, and it is probable that closer search will show their existence.

It is evident that the lavas were poured out in a very liquid state, and that they spread themselves in wide sheets of small depth over large areas of country. It is quite possible that the more earthy beds which form a very large proportion of the whole may have issued in the form of volcanic mud, not necessarily at high temperature. But the crystalline basalts were in all probability poured out as lavas liquified by heat.

Geologists generally have hitherto explained these peculiar phenomena by supposing that trap rocks similar to those of the Deccan have been poured out at the bottom of the sea, and in taking a different view, which I do with some diffidence, I know that I am in opposition to all the best authorities and to some at least of my own colleagues. It is considered that lavas would preserve their liquidity longer at the bottom of the sea under the pressure of the water; that they would consequently be spread over a large area; that there would, for the same reason, be vesicular structure, but not scoriaceous, and that cones of scoriæ would not be formed, because the ashes and fragments blown out from the crater would be spread over the bottom of the sea.

To this view there is one serious objection, which is, that some of the Deccan traps were subaërial or poured out in water so shallow that the pressure could not have affected them, and that these are undistinguishable from the mass of the beds; whilst, on the other hand, there is no evidence except the single occurrence of marine shells interstratified with the basalts near Rájámahindri to show that any portion of them were accumulated beneath the sea. In the case of Rájámahindri there can be no doubt but that some of the traps are submarine, and there can be equally little doubt but that they were poured out in a shallow sea or estuary close to land, for the marine shells found are of littoral or estuary species, not of deep water forms, and freshwater shells are mixed with them. It is equally clear that the bulk of the intertrappean sedimentary beds to be presently mentioned, wherever they are found from Mundla to Bombay, and from Dewad (Dhawud) in the Rewa Kanta to the Sichel hills of Hydrábád, are of freshwater origin, formed in small shallow lakes, and that consequently the greater portion of the surrounding country, over which the lava flows were poured out, was dry land.

Another proof that the lowest traps were subaërial is to be found in the form of the surface on which they rest. This is excessively uneven, valleys upwards of a thousand feet deep being found in it in places. This uneven surface can only have resulted from subaërial denudation; marine denudation, as has been amply shown, reduces the area affected by it to

* The reported eruption of this "volcano" in 1819 must be a mistake. There is no trace of any recent igneous action on the hill, which is not a volcanic cone, but a nucleus of basaltic rock exposed by denudation.

a plane. Had this surface, thus formed by the action of rain and rivers, been depressed beneath the sea before being covered up by trap, some traces of marine deposits must in places have remained at the base of the volcanic rocks conformably underlying them. But nothing of the kind occurs. The Lametá beds are of freshwater origin, and the Bâgh beds, which are marine, afford evidence of having been raised above the sea and acted upon by streams and rain before the lavas overflowed them. Now, the bottom flows are frequently some of the most compact and crystalline met with; they are as widely spread and as horizontal as any of the others. The same is the case in Bombay Island with the topmost flows; the basalt of Malabar hill, which rests on the freshwater shales seen at its base, is perhaps the most compact and most clearly stratified flow in the island, and that it must originally have been horizontal from Valúkeshwár to Warli, upwards of four miles, is evident, for it rests conformably everywhere throughout that distance on the sedimentary beds. If then the rocks at the base of the series throughout a large area, and those at the top at Bombay, are of subaërial origin, and these beds are as compact, as crystalline, and as distinctly stratified as the intermediate flows,–if, in short, there is no lithological distinction between the flows which are proved to have been poured out on the land and the great mass of the beds,–it is surely illogical to assert that the traps in general are submarine without adducing any other argument than their lithological characters.

The whole thickness of the traps cannot be less than 5,000 feet, probably it is more. The time occupied in their accumulation must have been great, for the sedimentary beds intercalated prove large periods of repose, during which lakes were formed and became stocked with living animals; and it is impossible to say how much of the interval between the Middle Cretaceous and the Eocene epochs was occupied in their formation. As before stated, they rest upon the Bágh beds, which are of Upper Greensand age; while upon them, after a break marked by great denudation, rest the Nummulitics, which are Eocene.

So far as physical evidence is concerned, the break at the base of the traps in the Narbadá valley appears less than that which separates them from the overlying Nummulitics near Súrat. In Kachh, a group of ferruginous clays intervenes between the traps and the Nummulitics. For these reasons I am myself disposed to look upon the lower traps at least, and consequently on the freshwater beds of the Narbadá valley and Nágpúr, as probably Cretaceous. But most geologists are inclined to class the whole of the volcanic series as Eocene.

The traps cover the whole of the Bombay Presidency from the Narbadá river as far south as the parallel of Goá in the neighbourhood of Belgáon and Kaladghi. North of the Narbadá in the Rewa Kanta they occupy but a small area ending abruptly south of Chota Udepúr. Powágarh hill is an isolated mass; and there is a larger tract composed of them around Dewad. A belt of them extends partly across Káttiáwár, and another, five to ten miles broad, throughout the greater part of Kachh, the dip being to the south. Traces may perhaps be detected farther to the westward, as at Ránikot in Sind, but no absolute proof of their existence has been found.

Intertrappean beds.—To these reference has just been made. The most important are limestone, calcareous shale, chert, and more rarely sandstone, containing in abundance remains of plants and freshwater shells, the most common being *Physa, Lymnea, Paludina, Melania, Unio,* &c. The beds containing these fossils have not hitherto been found more than 300 or 400 feet above the base of the traps. Each bed can rarely be traced for a longer distance than three or four miles, and seldom exceeds 2 to 3 feet in thickness; but successive beds are met with, trap flows intervening, sometimes as many as three sedimentary intercalations being met with one above the other, and often differing from each other in mineral composition and in the fossils contained. That these beds have been deposited upon the underlying trap, and that the overlying flow has been poured over them, is clear, because the upper surfaces of the freshwater bands are always hardened and altered (though sometimes to a very slight degree) and their base is unchanged.

In the Bombay Presidency, the only known localities for these "Physa beds," as they have been called from the prevalence of that shell (they are the Tákli beds of Hislop), are near Dewad (Dohud) in the Rewá Kántá (Rogers, Quart. Jour. Geol. Soc., 1870, p. 118,) and in Western Kachh, where they have recently been found by Mr. Fedden, of the Geological Survey, and near Kaladghi, where Mr. Foote, of the Geological Survey, discovered a thin bed of sandy marl lying beneath the lowest trap flow and the gneiss.

Near Gokak, in Belgáon district, Mr. Foote found fossil *Unios* in a thin bed of sandstone resting on a flow of amygdaloidal trap, which forms locally the base of the trap series, and was poured out over the rugged surface of the gneiss. The sandstones overlap the amygdaloid bed in places, and rest directly on the gneiss.

The intertrappean beds of Bombay belong to a very different horizon, being intercalated with the very highest trap flows hitherto explored, and their fossils are distinct, with one exception (a species of *Cypris*), from those found in the lower group of sedimentary deposits. The Bombay intertrappeans are composed of shale, and are of freshwater origin, as is proved by their containing frogs, freshwater tortoises,* *Cyprides*, remains of insects, and land plants. As in the group near the base of the traps, there are in Bombay several successive deposits with lava-flows intervening. They have been traced into the island of Salsette, but not farther, probably for want of searching for them.

The origin of these freshwater deposits is easily conceived. Flows of lava spreading over an uneven land-surface, cut into hills and valleys by subaërial denudation, must have dammed up the valleys of streams and converted them into lakes. Other flows might fill up the first lakes, but by isolating fresh hollows would produce fresh ones, for the flows, however liquid, could not have presented an absolutely plane surface, and the outbursts from different foci must have crossed and dammed up the hollows between flows from the same crater. The absence of sedimentary beds in the centre of the series may be due to the greater rapidity of deposition or to the peculiar climate produced by the wide spread of volcanic outbursts and to want of rain.

It is rather singular that fossils should be so much more common in the beds intercalated with the traps than in the Lametás at their base, although such shells as have been found in the latter are apparently similar to those met with in the former.

The traps and their associated beds have been treated at somewhat greater length than the other rocks on account of their great importance in Bombay, and the remarkable geological interest attaching to them.

V.—Older Tertiary Series.

The last of the great rock systems in ascending order is far less thoroughly known than most of those lower in the series. Although the abundance of organic remains found in it, foraminifera, corals, echinoderms, and mollusca in the lower beds, and bones of vertebrata in the higher, have attracted attention, not only in India, but amongst the palæontologists of Europe, very much remains to be done before the sequence of beds and their faunæ can be said to be properly known. It has been pointed out, and with every appearance of probability, that the fossil forms from Sind described in the "Description des animaux fossiles du groupe nummulitique de l' Inde" by M. M. D'Archiac and Haime must have been derived from formations varying to a considerable degree in age, and it is highly probable that a thorough examination of the Sind rocks will show the necessity of sub-dividing them to a far greater extent than has hitherto been attempted.

* The frog named *Rana pusilla* by Owen has been shown by Dr. Stoliczka to be an *Oxyglossus*. The tortoise named *Testudo Leithi* by Dr. Carter is not a *Testudo* (as indeed has been shown by Dr. Carter), but belongs to *Emys* or some allied genus.

In the present state of our knowledge it appears to be most in accordance with what information we possess to include in the older tertiary series all the rocks in Western India above the trap up to and including the beds of Perim and the Siválíks. It is true that Dr. Falconer has pointed out the connexion between the fauna of the Siváliks and that now living, and the absence of any great break in the chain of life; and it is possible that when the Indian tertiary formations are better known, a different sub-division to that now proposed may be desirable; but at present all that can be said is that the *series* as here proposed does appear to exist in Western India, and that, so far as is known, there is a break at its close.

So greatly do the beds of the Tertiaries vary, and so little has been done towards their correlation, that it is impracticable to describe them so generally as has been done in the case of the older formations; and, in order to give a fair idea of them, it is necessary to explain briefly the succession of beds in the different districts in which they are found, commencing in eastern Gújrát and thence tracing them across to Sind. The general succession appears to be sandy and argillaceous beds deposited in part in rivers or estuaries, and containing remains of land plants and animals at the top and base, and marine beds, some of them limestones formed in deep water, in the middle of the series. This is especially the case to the westward.

Súrat and Bharoch.—At the base of the tertiary formations near Súrat are thick beds of ferruginous clay assuming, where exposed, the characteristic brown crust and pseudo-scoriaceous appearance of laterite, from which they differ in no respect. These at first sight appear to be of volcanic origin, an idea which is strengthened by the neighbourhood of the traps on which they rest, but close examination has shown that they are really sedimentary deposits, although composed in all probability of materials derived from the disintegration and denudation of the trap. With them are interstratified beds of gravel or conglomerate containing agate pebbles (the agates derived from the trap), and limestone, sometimes nearly pure, but more frequently sandy, argillaceous or ferruginous, and abounding in nummulites and other fossils, many of them identical with those found in Sind and in the Eocene rocks of Europe.

Above the limestones and laterite beds there is found a great thickness of gravels, sometimes cemented into a conglomerate, sandy clay and ferruginous sandstone, often nodular. These contain fossils also, though not in such abundance as the lower limestones, and the species are different and perhaps belong to a higher horizon. Hitherto, however, they have not been properly examined and compared. There is some evidence in favour of unconformity between the two groups; the lower, which is well seen about Tarkésar and Gula east of Súrat, being apparently overlapped by the higher beds to the northward.

These higher beds are but poorly exposed in the Tapti river near Gutta and Karjan, and in the Kím between Kimamli and Elao, but they are well seen in the stream which runs past Ratanpúr east of Bharoch. Here they consist chiefly of sandstone, gravel, and conglomerate, with occasional beds of red or white clay and shales. The pebbles in the gravels and conglomerates are mostly of agate and other quartzose minerals derived from the traps; and from some of these beds the carnelians and agates are obtained, which have from time immemorial supplied the lapidaries of Khambayát.

The Eocene rocks in Súrat and Bharoch form merely a fringe along the edge of the traps; and they are covered and concealed to the westward by alluvium. A few traces of them have been found south of the Tapti, but none have hitherto been detected north of the Narbadá.

Perim Island.—The rocks of Perim Island in the Gulf of Khambayát are isolated; and it is difficult to say whether they belong to the group just described, or whether they are a portion of a newer formation altogether. In some respects they resemble the beds of the

Kím and Tapti. The island is small and flat, and the rocks being horizontal, very little is seen of them; the most characteristic bed is a coarse conglomerate containing blocks of fine sandstone and agate pebbles. With these are intermixed large masses of fossil wood and bones of various mammals, some of which have been identified with those of Sivâlik species. Amongst the remains found here are *Mastodon latidens*, *Sus*, *Dinotherium*, *Bramatherium*, and *Camelopardalis*. These mammals show the age of the beds to be Miocene.

Káttiáwár.—Ossiferous conglomerates like these of Perim are found also on the Káttiáwár coast near Gogo, though bones appear to be less abundant than at Perim. The conglomerates rest upon thick blue clay. These beds extend as a very narrow belt along the Káttiáwár coast to the neighbourhood of Gopnáth. Here they are replaced to a great extent by mottled clays and coarse rubbly limestone, fossiliferous in places, upon which rests a fine-grained calcareous rock known as milliolite, which apparently marks a higher horizon and will be described amongst the later Tertiary beds.

The rubbly limestone and clay is not fossiliferous near Gopnáth, but becomes so farther to the west. From Safirábád to Patan it is concealed by milliolite; but still more to the westward it is exposed in places and abounds in Eocene fossils.

Kachh.—The Nummulitic rocks and their associates are only found in the western part of Kachh, being overlapped by higher beds east of the neighbourhood of Mandavi. At their base, however, are some variegated clays and beds of laterite which have a much wider distribution. These beds are conspicuous from their brilliant contrasts of colours, red, purple, and white, many of them being highly ferruginous. They sometimes contain pebbles of agate, and upon them rest coarse sandstones and red, brown, and white shales with impressions of land plants. The thickness of this group varies from 20 feet to about 200, increasing towards the north and east. They appear in general to rest conformably on the traps, and it is possible that the lowest beds which have in places a very ashy appearance may have been formed before the termination of the volcanic action to which the subjacent traps were due. This at least is Mr. Wynne's opinion. Nevertheless these clays and laterites locally, as at Mharr and near Lakhpat, overlap the whole of the traps and rest upon the underlying jurassic beds, a circumstance which appears rather opposed to their being really conformable to the traps.

Upon these variegated clays, in the western part of Kachh, rest conformably fine laminated shales, containing plant remains in places, and pyritous and bituminous towards the base. The fossils both in these beds and in the variegated clays are chiefly leaves, endogenous and exogenous. As will be seen presently, these pyritous shales and richly coloured clays with plant fossils are well developed in Sind.

The general section of the Nummulitic beds in Kachh above the plant beds is the following, as abridged from Messrs. Wynne and Fedden's report:—

DESCENDING SECTION.

	Ft.
1.—Clays and shales occasionally sandy, with hard bands of shaly limestone or of marl, and a few sandy and conglomeritic beds. The upper portion highly fossiliferous	800 to 1,200
2.—Sandy shales, mottled white or ferruginous, irregularly bedded, with impressions of leaves	100
Dun-coloured and blue silty clays and shales, with minute crabs	30
3.—Nummulitic marls and limestones—Fossils numerous ...	700
4.—Gypseous shales and marls, with foraminifera, oysters, &c.	100

These are not regularly interstratified; some of the divisions are of local occurrence, No. 2 being only found on the flank of the Gaira hills, and a few other places, while No. 4 is also deficient in places. The thickness given is approximate only.

The nummulitic group, No. 3, consists of pale, yellow, and white argillaceous limestones with some sandy beds and shaly marls. The massive and compact nummulitic limestones of Sind do not appear to extend to the westward.

The argillaceous group, No. 1, is the most important of all in Kachh, and it contains the greatest number and variety of fossils. It perhaps represents the clays and limestone of Káttiáwár, and it may be the equivalent of the gravels and conglomerates of Ratanpúr near Bharoch. But it is far from clear that this is the case.

West of Kachh the delta of the Indus makes a great break in the belt of tertiary deposits bordering the coast, and when the rocks again emerge from beneath the alluvium in Sind, the border groups of India have been left behind, and the great nummulitic limestone tract entered, which extends from the Himálayas to the Mediterranean. In Sind itself no rocks older than the Tertiaries are known to occur, but to the west in Kelat, mesozoic and palæozoic strata have been found by Dr. Cook, which are probably a continuation of the beds known to exist in the Salt Range.

The following general section of the beds in Sind is given by Captain Vicary:—

1.—Conglomerate.
2.—Clays and sandstone.
3.—Upper bone bed.
4.—Sandstone—fossils rare.
5.—Lower bone bed.
6.—Coarse, arenaceo-calcareous rock, with *Cytherea exoleta?* and *C. exarata*, *Spatangi*, no nummulites.
7.—Pale arenaceous limestone with *Hipponices*, *Nummulites* and *Charoideæ*.
8.—Nummulitic limestone of the Hálá range.
9.—Black slates—thickness unknown.

Probably a thorough examination of the country would produce some important modifications in this list. What the black slates No. 9 may be it is difficult to say from Vicary's description, as he does not refer to them further, and it is doubtful if they occur within the limit of Sind.

Beneath the limestone of the Hálá range and of Kotru (Kotree), which appear to be identical, there is a great thickness of variegated sands and clays containing leaves of plants, and in one or two places small lenticular beds of lignite. These beds undoubtedly represent the somewhat similar formation below the nummulitic marls and limestone of Kachh. A rough classification of the Sind rocks, so far as they are known, may be attempted thus:—

DESCENDING SECTION.

1.—Conglomerates, clays and sandstone with fossil bones; (Nos. 1 to 5 of Vicary). These are the equivalents of the Siválik and Perim beds, and are known to be of Miocene age.

2.—Limestone, more or less pure, passing into sandstone and of variable character (6, 7, and 8 of Vicary.) Towards the base are massive beds of white limestone of great thickness abounding in *Alveolina*, a small spheroidal foraminifer. It is highly probable that further examination will show the necessity of sub-dividing this group.

3.—Variegated sands and gypseous clays, with remains of plants.

At Karáchi itself the only rocks seen belong to newer beds than any of those now described, but to the north-west near Magar Pir an impure limestone is met with, containing numerous mollusca and operculina, but nummulites are scarce if they occur at all. From Karáchi to Kotru (Kotree) various forms of nummulitic limestone cover the country. Near Kotru itself white compact limestone with *Alveolina* is found, whilst to the westward, a considerable area is covered by the variegated sands and clays. Amongst these, north-west of Kotru, occurs the lignite of Lynyan, an attempt at mining which was once made. The quantity of the mineral was, however, found to be small owing to the rapid thinning out of the bed, and the quality was inferior.

At Ránikót, a gorge in the Eri hills, twenty miles west of the Indus at Magendan, and forty-five miles north-west of Kotru, about 1,000 feet of massive alveolina limestone rests on 1,300 feet of variegated sands and clays, at the base of which trap is seen. Whether this trap be intrusive or not has not been ascertained; it appears stratified and is slightly amygdaloidal. Of course, the occurrence of igneous rocks below the lowest of the rocks known to be associated with the nummulitic limestones recalls the similar association of variegated clays resting upon traps, these unmistakeably belonging to the Deccan series, in Kachh; but it has by no means been definitely ascertained whether the trap in Sind is a representative of the Deccan series. The Eri hills are an outer ridge of the Hálá range and terminate to the north at Sewan. The Hálá range stretching along the frontier is said to be entirely composed of limestone. Further to the north, and to the north-west of Sewan, conglomerates and sandstones of Siválik age with mammalian bones are found along the flanks of the main limestone ranges. The greater part of Upper Sind is an alluvial plain.

Laterite of the Deccan.—Although the age of the laterite found locally on the crest of the Sahyadri and in the southern Marátha country is extremely obscure, there appears some probability from its mode of occurrence that it should be referred to the older and not to the newer tertiaries. Its occurrence in isolated caps on various hills appears to indicate that all now seen is merely the remnant of a formation once far more widely spread, and its striking resemblance to the beds already mentioned as occurring in the Nummulitics of Súrat renders it possible that the two may be of the same age.

Laterite is essentially a clay strongly but unequally impregnated with iron peroxide, to which it owes its deep red colour, which, however, is far from uniform, the surface of a freshly broken fragment being veined and mottled with different tints, from white to deep red. Sometimes the appearance is almost that of a breccia from the angular white fragments enclosed. In some places, as at Bidar, the rock is intersected by small irregular tubes, lined with hydrated peroxide of iron, but these are not always present. The surface has a very characteristic appearance, being very irregular, owing to the washing away of so much of the clay as has not been impregnated with iron, and being covered with a glazed coating of hydrated iron peroxide or brown hæmatite. In the newer forms of laterite (for the rock is of various ages) grains of quartz and small pisolitic ferruginous concretions are usually found in considerable numbers, but in the rock which occurs at high elevations in the Deccan these are often deficient.

Of the origin of this singular rock but little can be said. In consequence partly of its peculiar pseudo-scoriaceous appearance, and partly of its occasional passage into decomposed trap at its base, it has by many geologists been classed with the volcanic rocks. But it has never been found intercalated with traps, and it is met with interstratified in the sedimentary Eocene strata; moreover, its conformity to the trappean flows is only apparent, since the same laterite is found in some places resting on traps much lower in position than in others, *e. g.*, at Mahableshwar and Panchgain, it rests upon flows very high in the series, while at Mátherán and Khandála it is found on much lower beds. It is therefore fairly evident that the Deccan laterite is a rock of aqueous origin and newer than the volcanic series, from the detritus of which it is probably formed; but by what process it has accumulated—whether it be of marine, fluviatile, or subaërial origin—is extremely difficult to say, the more so because, as is frequently the case in highly ferruginous rocks, no fossils are found in it.

Laterite has a remarkable power of resisting disintegration, and wherever a cap of it is found on a hill, the lower ground around, if sufficiently flat, is covered with a thick coating of reconsolidated débris. The iron washed out of the laterite tends always to change any decomposed rock, such as trap or gneiss, beneath it into a substance so precisely resembling the laterite itself that there is generally an apparent passage from one rock to the other.

VI.—Upper Tertiary and recent beds.

Of these rocks, like the last, the classification as yet is most imperfect; indeed the line drawn in some places between them and the beds described in the last section is quite arbitrary. It is possible and even probable that some of the formations here included in each may ultimately have to be placed in the other series.

Upper Tertiary beds of Káttiáwár.—Along the coast of the Káttiáwár peninsula a fine porous calcareous rock occurs, which is widely known as milliolite, or Porbandar stone, and exported under this latter name to Bombay for building purposes. It was found by Dr. Carter, who examined it, to consist of minute foraminifera with a few grains of quartz and hornblende. This rock varies much in mineral character in different places; near Gopnáth point, which is its easternmost extension, it is much less pure than to the westward, being much mixed with clay. It is everywhere strongly marked by irregular oblique lamination or false bedding, showing deposition by currents.

Except the foraminifera the only fossils hitherto found have been *Pupa insularis* and some other recent species of land shells which Mr. Theobald obtained. The occurrence of these shells is the principal reason for placing the bed amongst the newer Tertiaries; although, as some existing forms are said to occur also in the Siváliks, the evidence must not be considered as conclusive. Of the thickness attained by the milliolite nothing trustworthy is recorded. It is found throughout nearly the whole south coast of Káttiáwár.

Upper Tertiaries of Kachh.—In Kachh, there is a higher sub-division of the Tertiary beds, chiefly developed to the westward, that is, in that part of the province in which the older Tertiaries are wanting, and apparently unconformable to the latter. The following is the section given by Messrs. Wynne and Fedden:—

Descending.

Variable deposits, including concrete beds of great thickness.

Soft sandstones, shelly, calcareous and quartzose grits, gravels and conglomerates with trap pebbles and agates.

Brown sands and sandstones with fossil wood.

The thickness varies from 200 to 500 feet. The only distinguishable fossils are some large oysters, which are met with in the thick obliquely laminated concretes of the upper group. These oysters closely resemble the species now living on the coast of Kachh. It is not at all clear whether this concrete represents the milliolite of Káttiáwár, or the sub-recent calcareous shelly rock to be hereafter described.

Ossiferous gravels of river-valleys.—In parts of the Narbadá and Godávari valleys gravels have been met with containing bones of extinct mammalia much more nearly allied to existing forms than are the species found in the Siváliks. In the Narbadá, the deposits of which have been far more fully explored than any others, the bones belong to species of *Elephas, Hippopotamus, Sus, Equus, Bos, Cervus, &c.*, associated with fluviatile shells of existing species. The age of these beds is by Dr. Falconer considered to be Pliocene.

A skull belonging to *Elephas Namadicus*, one of the Narbadá species, molars of *Bos*, and some other bones have been found in the banks of the Godávari near Paitan (Pyton) on the road from Ahmadnagar to Jálnah; and in the same gravel a well-marked agate flake, which has every appearance of human manufacture, was obtained by Mr. Wynne in 1865.

There is every probability that these bone-gravels are dispersed over a large portion of the country, and enormous quantities of bones have been occasionally exposed in the Godávari valley. An elephant's tusk was exhumed some years since by Dr. Cook near Satárá, and during the present year (1871) information has been received of the discovery (in Rígar) of a rhinoceros skull by Mr. Foote in the valley of the Gatparbá near Gokák. It is singular that no fossils have hitherto been obtained from the Tapti valley in Khandesh.

Surface gravels of Sind.—The plains of lower Sind to the west of the Indus and in the neighbourhood of the Hálá range are covered over to a considerable depth with gravel, composed of limestone and sandstone pebbles derived from the hills. In places torrents have cut through thick accumulations of these beds. It is evident that these gravels consist of detritus carried down by the wash of rain and streams; but from the denudation they have undergone in places portions of them must be of considerable antiquity. No organic remains appear to have been found in them; but they are worthy of closer examination than they have hitherto received.

Laterite of the Konkan.—The laterite of the western coast is of later date than that of the Deccan; and its derivative nature is proved by the occurrence of sand and small pebbles; yet, except in being more sandy, it closely resembles the older rock, from the detritus of which it may be partly derived. It occurs as a thick bed capping the traps and forming a plateau at a general elevation near Ratnagiri of between 200 and 300 feet above the sea. It had once covered the whole country; but numerous ravines have been cut out of it by streams. At Ratnagiri there is a bed of white clay containing remains of plants below the laterite.

The mode of formation of this rock in the Konkan is nearly as obscure as in the Deccan; but its position in this case renders it more probable that it may have been originally a submarine formation, deposited at a period when the Konkan was at a lower level and the sea washed against the cliffs of the western ghâts. It is not easy to say whether this really was the case, but there is no improbability in it. The deposit may have been greatly changed by subaërial action after its emergence.

Laterite is not found far north of Ratnagiri, and near that place only extends about fifteen to twenty miles inland. It extends farther towards the foot of the ghâts near Phonda ghât, but in Sawantwari is again limited to a band ten to fifteen miles broad. It covers a considerable area in the Goa territory.

Patches occur at a lower level scattered over the country; but these consist of a kind more mixed with gravel and sandstone. The peculiar character of this rock and the tendency of the detritus from it to reconsolidate must always be borne in mind when examining it.

Alluvium of Sind, Kachh and Gújrát.—In the north-western part of the Bombay Presidency there are extensive alluvial plains to which, in a sketch of the geology of Western India, a few words must be devoted. The sands and clays of which they consist are river-valley and delta deposits, washed down by the streams, and accumulated in the lower portions of their course and at their mouths. By far the most important of these compose the great plain extending to the east from the Indus.

A glance at the map will show that from Háidarábád in Sind to Ahmadábád in Gújrát is an almost unbroken flat. This flat is the south-western extremity of the great plain which stretches across Northern India and comprises the valleys of the Indus and Ganges. That this plain was at one time an open sea is suggested partly by the line of division which it forms between the two entirely distinct geological provinces of the Indian peninsula and the Himálayas, partly by the Tertiary marine beds which fringe so large a portion of its edges. The high grounds of Kachh and Káttiáwár are surrounded on all sides by portions of this flat or by the sea.

There appears much probability that the conversion of this vast area into land has been due in great measure to the silt, sand and gravel brought down by the various streams and rivers which emerge from the Himálayas and Bilúchistán on one side and from the Indian peninsula on the other. The process has doubtless been gradual and is still in progress. Locally, elevation may have aided, but, on the whole, there is probably at least as much reason to assume depression to have been the prevailing movement of the surface.

The Ran of Kachh appears to have been an inlet of the sea which has been gradually filled up by the silt deposited from the streams which enter it. This tract of country is still in a debateable condition, being covered with water in the south-west monsoon, when the floods brought down by the Banás and Loni, and by the small streams of Kachh, are forced back by the waters of the Gulf of Kachh and the old Korí mouth of the Indus, raised above their usual level by the force of the south-west wind, whilst during the remainder of the year the whole region is dry land, except in patches. There is a tradition that, at no distant period, the Ran was a navigable inland sea; and the appearance of its shores, with the occurrence of subrecent marine deposits, confirm this idea, although the period of its conversion into dry land remains doubtful, the evidence of the discovery of old boats being confined to localities which may have been covered with water after the greater part of the region was dry land.* Formerly it is probable that the eastern branch of the river Indus discharged itself into the Ran, and the quantity of silt deposited may have been much greater than is now the case.

On the eastern side of Káttiáwár the Gulf of Khambáyat is also said to be silting up. The evidence as to the rapidity of the process is not conclusive, but it may fairly be assumed that a gradual extension of the coast is taking place. On the east of the gulf, the Sábarmati, Málu, and Narbadá, the last being one of the great rivers of the Indian peninsula, all discharge themselves; and the quantity of silt and detritus brought down by them must be very great.

That the Gulf of Khambáyat once communicated with the Ran is probable, as a belt of low land, including the brackish marsh known as the Nal, still connects them. Mr. Rogers (Quart. Jour. Geo. Soc., 1870, p. 118) has pointed out that while the black soil of southern Gújrát is probably derived from the neighbouring trap rocks, the light-coloured alluvium to the northwards may have been brought down by the rivers flowing from countries still further to the north; and he has speculated on the possibility of the Indus having once discharged its waters in this direction.

Elevation may also have played its part in the conversion of these alluvial tracts into dry ground; and there is better reason for suspecting its action here than farther to the northward; for, along the south coast of Káttiáwár marks of a comparatively recent rise are numerous. In a MS. report by Mr. Theobald, written in 1858, mention is made of the occurrence of barnacles and serpulæ on the foundations of an old building beside a creek at

* Nothing appears to be said of any sea north of Kachh by the Buddhist-Chinese travellers of the seventh century.—*See* Cunningham's Ancient Geography of India, Vol. I, p. 302.

Pátán, which are now only reached by high floods; and dead oysters, evidently quite recent, were found in various creeks and especially in one at Porbandar, 20 feet above the level at which they now live. The evidence collected by Mr. Theobald appeared to show that a rise of 10 feet had taken place in the course of the year 1856. The changes of level in the Ran of Kachh during the earthquake of 1819 are well known, but in that instance, elevation of one tract was accompanied by depression in another. The vast expanse of water which Sir A. Burnes found around Sindri in 1828 has, however, now been mainly reconverted into dry land; and Mr. Wynne in 1868 reached the ruins of Sindri fort from Kachh on a camel. This change appears due to the deposition of silt, the cause to which may be attributed the conversion of the whole Ran into a land area.

Alluvium, besides occupying the delta of the Indus, the Ran of Kachh, the southern coast of the same province, and a large tract extending northward and eastward from the Gulf of Khambáyat, covers nearly the whole of Súrat district, and occupies a considerable proportion of the country to the southward, forming plains which, near the coast, intervene between the trap hills as far south as Bombay. It appears probable that some of the hills in the Northern Konkan have been promontories or even islands in the sea, and it is recorded that within historical times the hills of Bombay island were unconnected with each other. Their union has been due partly to artificial means, but chiefly to the accumulation of sand and silt. Unquestionably, unless man interfere, or some great change take place in the configuration of the country, the harbour of Bombay, the sole survivor of the inlets, which must once have been numerous, must be gradually silted up in the course of age. But as no stream of importance enters the harbour, the process is not likely to be so rapid as to cause serious concern as yet to those interested in the commerce of the port.

Littoral concrete.—An agglutinated calcareous mass of shells and gravel is found in many places along the coast. Some is seen in Bombay island, the esplanade consisting of it, and a part of the fort being built upon it; it also occurs at Mahim and in places on the shores of the harbour. To the northward it is met with here and there as far as Damán; it may show slight elevation of the coast line, but the amount of rise is very trifling.

Upon the milliolite of Káttiáwár the same formation is much more largely developed. It here assumes the appearance of a calcareous grit, containing marine shells and corals, and occasionally attaining a thickness of 60 feet. The species of animals found in it are, so far as is known, identical with those now inhabiting the coast. The evidence thus afforded of a recent elevation is an addition to that previously quoted.

Black soil.—Soils scarcely enter into the geology of a country, as they are simply the surface altered by exposure, organic agency and agriculture, but it is impossible entirely to overlook the widely spread "rigar" or "cotton soil." This is a black, grey or brown loam, varying much in character; tenacious and adhesive when wetted; light, crumbling and intersected by cracks when dry. It is found throughout the trap area, being in this instance a product of the decomposition of the volcanic rock, and every step in the passage from one to the other may often be witnessed in small roadside sections. It does not, however, follow that all soils derived from the trap are black, nor that no black soil is produced by the decomposition of other rocks. Red soil is often seen within the trap area; and true cotton soil, inferior in fertility, however, to that produced by the volcanic formations, is met with in Southern India, in the Káveri valley for instance, in a country which there is no reason to suppose ever contained trap. A very similar black alluvial deposit forms in the back-waters of the coast.

"Rigar," in short, appears to be a more or less argillaceous soil, impregnated with organic matter.

In the preceding sketch no attempt has been made to write a geological history of the country; for that purpose far more data must be accumulated than are at present available. Very much remains to be done before the geology of Western India can be said to be even tolerably well known. Of the rocks in many parts of this immense area, no descriptions exist except occasional notes collected by travellers; and even in the portions to which the Geological Survey has been extended, the examination has, in many cases, been but partial and preliminary. There is yet a wide field open to the geologist and naturalist, and there is no part of India which will in all probability more thoroughly repay careful search and enquiry than the Bombay Presidency. The chemical and lithological peculiarities of the trap formations and the minerals contained; the fauna and flora of the intertrappean beds; the multitude of organic forms in the Nummulitic rocks of Gújrát, Kachh, and Sind; the mammalian bones of the Miocene and Pliocene conglomerates and gravels;—all promise a mass of important discoveries to any one who will devote time and labour to their investigation.

W. T. BLANFORD.

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L'ADMINS. DES MINES.

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London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 4th Ser., Vol. XLII, Nos. 283-287, (1872), 8vo., London.

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" Zeitschrift der Deutschen Geologischen Gesellschaft, Band XXIII, heft 3, (1871), 8vo., Berlin.

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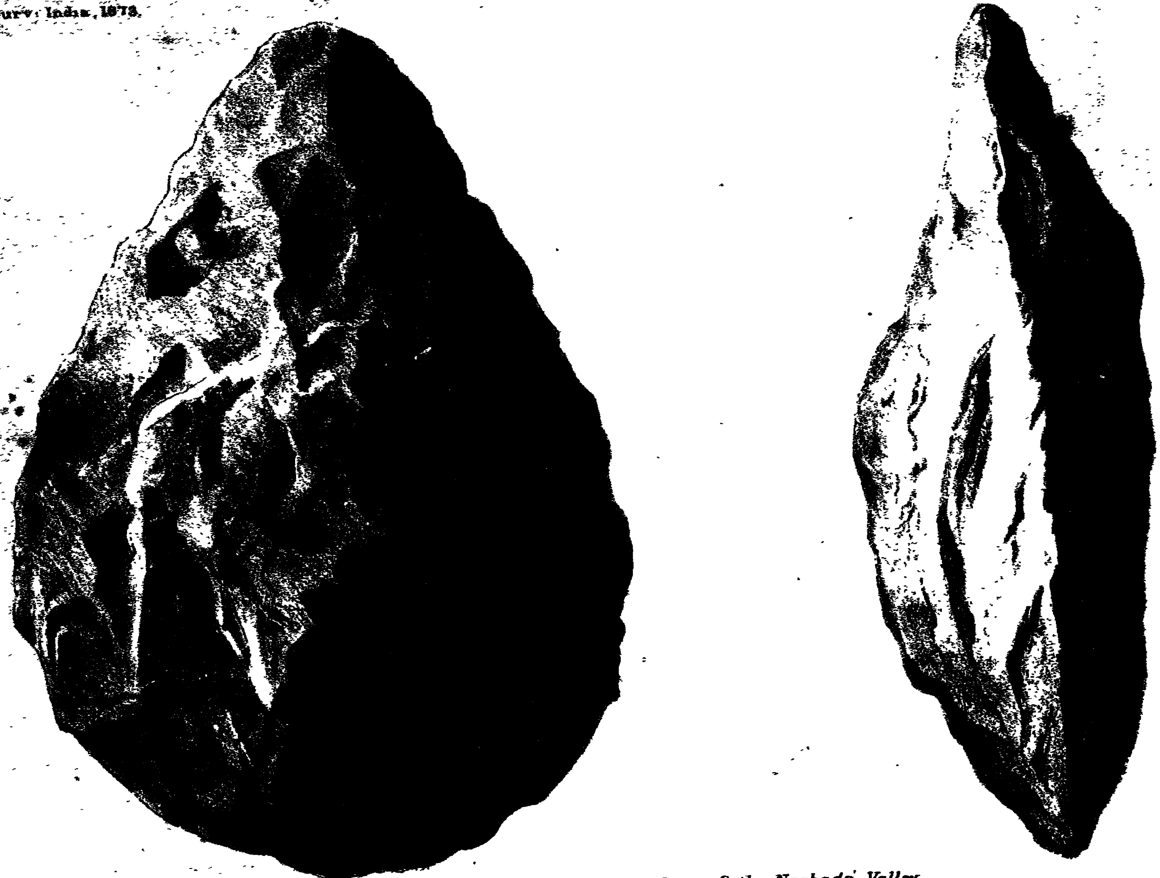
July 3rd, 1872.

Note.—The following mistakes escaped notice in the first part of the present volume:—

Page 18,	*line*	8,	from bottom,	*for*	Hæmatite	*read*	Tremolite.
„ 20,	„	3,		„	say	„	vary.
„ 20,	„	12,		„	chrysolite	„	chrysotile.
„ 20,	„	39,		„	and crystalline	„	to finely cryst.
„ 22,	„	4,		„	starry	„	strong.
„ 22,	„	5,		„	falls	„	fuses.
„ 22,	„	11,		„	white	„	rutile.



Stone implement found in the fossiliferous clays of the Narbada Valley, near Bhutrá, 8 miles north of Gádarwára.

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OF THE

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Part 3.] 1873. [August.

Notes on a CELT *found by* MR. HACKET *in the* OSSIFEROUS DEPOSITS *of the* NARBADÁ VALLEY (PLIOCENE *of* FALCONER) : *on the* AGE *of the deposits, by* MR. H. B. MEDLICOTT ; *on the associated* SHELLS, *by* MR. W. THEOBALD.

The celt is formed of Vindhyan quartzite, such as might be procured at any point along the northern edge of the valley; it is of the pointed oval shape, 5″ × 3″⅝, of very symmetrical outline (see figure); and, although rather roughly chipped on the faces, it is unquestionably a manufactured article. Mr. Hacket dug it out himself from where he found it lying flat, and two-thirds buried, in a steep face of the stiff, reddish, mottled, unstratified clay, about six feet above low water level, and about three feet below the upper surface of the clay, upon which there rested about twenty feet of the gravel with bones. From the edge of the cliff of gravel, there is a steep slope passing up through the ravine ground, so common along the border of the main river channels, to the general level of the plains, at 90 to 100 feet above the level of the Narbadá. The locality is on the left bank of the Narbadá, near the village of Bhutra, eight miles due north of Gadarwara.

The age of the ossiferous deposits.—In bringing forward an authentic specimen of human manufacture from the ossiferous deposits of the Narbadá valley, some expression of opinion will be expected from geologists in India regarding the age of those well-known beds; the more so because a name has been already applied to them by a high authority, implying an age very much more remote than that of any human remains as yet found in other countries. In all questions relating to the determination of vertebrate fossils, Dr. Falconer's judgment carries great weight. In India he has not as yet had a competitor in this line of research; and even in Europe he took a leading part in the same studies, connected with the inquiry into the antiquity of man. He determined a number of fossil bones from the Narbadá deposits, and invariably spoke of them as pliocene.

In 1868, the Superintendent of the Geological Survey described in these Records (Vol. I, p. 65,) an agate flake, or knife, found by Mr. Wynne in the ossiferous clays of the Godávarí valley, which he affiliated to like deposits in other parts of India. In this connection Falconer's views were quoted at length by Dr. Oldham in a tone of high approval, without any expression of dissent or of question as to the matter of age; and thus at least a tacit assent and a fresh lease of life was given to the opinion that these deposits belong to the pliocene age of geologists, the name being used by both authors in the confident expectation that these deposits would yield evidence of man's existence. I do not pretend that the question of age can be finally settled now; but it is important to point out that the opinion quoted is not well founded.

For those who are not posted up in such matters, it is well to point out the considerable historical license that is taken in this application of the name pliocene. In the accepted geological nomenclature the tertiary formations end with the newer pliocene. Although the post-tertiary period is as nothing compared with the preceding geological ages, it still represents a great lapse of time, for an estimate of which we are entirely dependent upon geological evidence. After passing the recent, or prehistoric, period, in which all the animals are of existing species, we get into the post-pliocene, or pleistocene, period, in which a variable proportion of the mammalian remains are of extinct species; and according to the distribution of these extinct mammalia, the deposits are arranged into late, middle, and early pleistocene. Nearly all the old river-gravels and cave-deposits with the human remains, about which so much has been published in the last few years, belong to the late pleistocene, or, as it is sometimes called, the quaternary period; this name being sometimes also used as equivalent to the whole pleistocene, and preferably so in my opinion, as distinctly marking its post-tertiary date. Thus it may be said roughly that the oldest human remains in Europe only take us about half-way back in that post-tertiary time. Almost the whole of the glacial period,—during which England was in great part submerged, and the glaciers of the Alps filled the great valley of Switzerland to high up on the flanks of the Jura,—intervenes between those ossiferous valley-gravels and the newer pliocene, or even the early pleistocene. Some supposed evidence of human remains has been brought forward from pliocene strata in England, and even from miocene beds in France, in the form of perforated shells, scratched and split bones, and very rudely-chipped stones; but the correctness of these interpretations has been denied by competent and quite unprejudiced judges.* It may, therefore, be said that from the stand-point of existing information, the genuineness of human remains from pliocene strata, or the true pliocene age of strata containing human remains, would call for particular proof; or, not to disguise the point, supposing (as seems almost probable) man to be an exalted chimpanzee, it is quite an open question whether the change may not have occurred in post-tertiary times—so little positive is still our knowledge of geologic time and of the method of organic evolution.

Even some geologists seem to need to be reminded that the tertiary period and its sub-divisions are based upon the testacea only, upon the proportion of living to extinct species of fossil shells, not of fossil remains in general. The fitness of this limitation was guaranteed in the first instance by the judgment of its distinguished author; and it has been justified by the universal adoption of the classification based upon it. It is with no small astonishment, therefore, that we hear of the grounds given by Falconer for calling the older deposits of the Indian rivers pliocene. After telling us (Pal. Mem., Vol. II, p. 644), on the authority of the Geological Survey, that the shells are all of existing forms, although in somewhat different proportions to those now inhabiting the Narbadá valley, he adds:—"In designating the formation as pliocene, which I have done during many years, I have been guided by the indications of the mammalian fauna, as intermediate between the miocene of the Irrawadi, Perim Island, and the Sivalik hills, and that of the existing period." That is, he takes upon himself to use the word pliocene in a sense quite foreign to that in universal use. The difference noticed here in the relative strength of the molluscan species in the living and the fossil stages is nothing like so great as that in the post-pliocene deposits of Europe. For the living relations of some of the species, even in the late pleistocene deposits of England, one has to go to the Mediterranean or to sub-arctic waters. The whole ground of Falconer's position is placed upon the mammalian fauna. The act is thus either a deliberate attempt to revolutionise the meaning of part of our best established geological nomenclature, or else the word pliocene is applied in a more abstract sense, im-

* Opinion may be reserved at present upon the miocene age of Mr. Calvert's fossil drawings.

plying that these deposits in India belong to the age of the pliocene of Europe. Falconer cannot be acquitted of the grave error involved in the former position; and one scarcely knows whether the error is aggravated or palliated by the fact that his judgment was here influenced by his temper. It is painfully evident in his later writings that he took a pleasure in ignoring and crossing the authority of Sir Charles Lyell. It was not only to Indian deposits that Falconer applied his independent criterion of classification: upon the evidence of the fossil mammalia he designated the well-known pre-glacial forest-bed of Norfolk as pliocene, in defiance of established usage (loc. cit., Vol. II, pp. 190, 586). One need hardly say that his attempt has been by common consent ignored. In a very recent note upon the classification of the pleistocene deposits, Dr. Boyd Dawkins points out the very marked difference even of the mammalia of the forest-bed from that of the pliocene (Am. Jour., April 1873).

The hint thus given to geologists in India is a very strong one; and the matter would scarcely have been worth notice but for the apparent sanction recently given to Falconer's words. We are in a manner bound to reject Falconer's criterion as such; and it only remains to be seen whether in some non-regulation sense the Narbadá deposits, and with them the old alluvium of the Gangetic plains, can be of pliocene age. It is of course conceivable, albeit in contravention of the harmonies of nature so far as known, that the mammalian fauna might be very strongly in favor of the position taken up by Falconer. Although the fossil shells all belong to species now living in the neighbourhood, the mammalian forms might (at least in argument) be of such antique types as to bear down the standard of the shells. Nothing of the kind, however, is the case. Falconer repeatedly insists, on the one hand, upon the perfect distinctness of the Narbadá fauna from that of the Sivaliks, and on the other hand, upon its strong affinity to living forms. He speaks of the Narbadá fossils as "in time only a little ahead of existing species" (op. cit., Vol. I, p. 21). He nowhere says that the Narbadá fossils are in any specific sense pliocene; but only, without any attempt at precision, that he calls the deposits pliocene because the mammalian fauna is intermediate between the miocene of the Sivaliks and that of the existing period. It is a great testimony to the authority of Falconer's name that an innovating opinion, without even an attempt at defence, should have met with any consideration. I do not, indeed, presume that Falconer's statement of age has ever received much countenance from students in Europe or elsewhere; but since an apparent approval of it has been issued by a high authority in India, it is well, on so fitting an occasion as the present, to examine the merits of the case.

As regards fossil man in India, Falconer's speculations were based a good deal upon biological assumption and geological misconceptions. It is not quite certain that *à priori* the oldest marks of intelligence that can be called human are to be looked for, as Falconer tells us, "in the great alluvial valleys of tropical or sub-tropical rivers." If the analogy of historical times may be taken into account, it would not be under conditions favorable to nakedness and laziness that we should expect contrivance to be born. We may indeed find the most monstrous form of the ape in the deposits of tropical regions; but it may be quite possible we should look for the earliest trace of humanity in the regions now most favourable to its development.

* Mixed up with Falconer's mythical, biological and physico-geographical speculation upon the cradle of the human race in India, there is frequent very vague mention of geological conditions; and here we come upon his weak point. It is an excellent example of a confusion very commonly made—showing how a man may be in the first ranks as a palæontologist, and in that sense a geologist, and yet possibly be a very poor geologist in the stricter and primary sense of the word. Although Falconer's clear instinct

of observation led him to the broad conclusion that the Sivalik strata were formed of débris conveyed through the existing river-channels (op. cit., Vol. I, p. 8), and deposited along the base of the mountains, it may almost be said that he never made a geological observation in any particular sense of the action. The most amazing instance of this appears in the explanation he gives of the absence of lakes along the base of the Himalaya, as compared with the Alps. He tells us (op. cit., Vol. II, p. 650,) that for ten or twelve years he puzzled over this problem on the ground; yet he accounts for the absence of lakes along the base of the Himalaya by there never having been glaciers to prevent the silting up of the basins. The absence of the basins themselves seems never to have occurred to him, although all the Himalayan rivers are rock-borne torrents in the region of the missing lakes.*

As more directly bearing upon the point before us, it would seem that, in the absence of such conspicuous evidence as the marine boulder-drift of Europe, separating the ossiferous valley-deposits from all the tertiary formations, Falconer failed to observe the very marked stratigraphical features that do occur. He speaks of there being no break visible in the tranquil succession of deposits; that "the present physical order of things, modified only by alterations of level, by upheavement and depression, could be traced back in an unbroken chain to the ossiferous strata of the valley of the Narbadá and of the Sivalik hills" (op. cit., Vol. II, p. 576, and Quar. Jour. Geol. Soc., London, Vol. XXI, 1865, p. 386); he constantly speaks of the Sivalik hills as "an upheaved portion of the plains of India." All this is exceedingly inaccurate and misleading. I have added many proofs to at least one point of Falconer's description, that of the distinct connection of the Sivalik deposits with the present local mountain-features; but the most cursory examination reveals to the geologist great gaps in the series of deposits. At Hardwar, a place well known to Falconer, the old alluvial clay of the plains is found resting upon a deeply denuded surface of vertical topmost Sivalik strata. The relation is stratigraphically similar, and probably nearly historically corresponding, to that of Loess of the Rhine to the Molasse of Switzerland. There is full evidence, too, that the glacial period was sensibly felt in these regions: in the Kangra valley, where a range of considerable elevation (the Dhaoladhar) occurs close to the edge of the low hills, I found unquestionable glacial erratics scattered over a surface of the Sivalik formations, at a present elevation of 3,000 feet above the sea (Mem. Geol. Sur., India, Vol. III, p. 155). I do not doubt that if we could fetch up a meridional slice of the Gangetic plains, we should find deposits representing the whole interval indicated; and it is not improbable that the series may yet be picked out from outcrops in different parts of India. What I want to show is that the two terms of the series we now have hold of—the old Gangetic alluvium and the Sivaliks—are very wide apart; and so, that the Sivaliks being older pliocene or upper miocene, the other may be ever so recent.

If we make any attempt to gauge the age of the old alluvium from the other side, we are led pretty much to the same result. All purely geological computations are estimates of work done; and we have the immense advantage of knowing that the operatives never idle, or never even take rest. The final appeal for the antiquity of the human remains in the valley-gravels and cave-deposits of Europe is not to the little-known laws and conditions regulating the extinction of species, but to the mechanical work done in altering the features of the country, in excavating wide valleys, or in laying out broad plains subsequent to the date of those remains. It is quite true that the result here, too, is only an approximation within wide limits; that the independent variables of the problem,

* It puzzled me to think upon whose observation Sir Charles Lyell could have adopted such a view as this, as stated in his "Antiquity of Man" (p. 319). The puzzle is now cleared up. If Sir Charles, as Falconer supposed, annexed information without acknowledgment, he did not always gain by the transaction.

while largely affecting the result, can only be indirectly conjectured. For instance, a change of levels would greatly affect the eroding and depositing power of rivers; or a change of climate and of rainfall, with perhaps the addition of severe frost, would have a like disturbing effect upon the work done, without our being able to assign the amount of those by-gone conditions. But taken all in all, reliable indications, and comparative, if not actual, measurement can be made.

The Narbadá valley, meaning that broad area of the river's course from where it leaves its gorge in the trappean plateau of Mandla near Jabalpúr, to where it enters its narrow gorge through the Vindhyan quartzites below Hosungabád, is about as unfavorable a case as one could select to exhibit symptoms of change. It is a rock-basin, a valley excavated chiefly, if not entirely, in crystalline and slaty metamorphic rocks, between two plateaus of little-disturbed sandstone-formations, the Vindhyan on the north and the Máhádévá on the south, and converted into a rock-basin by some oscillation of level. It would seem that the change was not rapid enough to produce a lake, for in all the sections now exposed coarse gravels occur. As soon as this basin had received the charge of deposits due to this change of level, and supposing no further earth-movement to occur, the change of features to what we now find would depend upon the eroding power of the river to lower the rim of the rock-basin, and thus gradually to bring under denudation the deposits it had so lately laid down. If then we could fix the maximum thickness attained by the deposits, and also the rate at which the river can lower its gorge of discharge, we could assign something like actual dates for the successive phases both of denudation and of deposition, on this supposition of normal conditions, without interference of crust movements or other occasional forces. The process is now going on. The river at least cuts faster than pluvial denudation can work in lowering the general surface, for its bed is now some 80 to 100 feet below the level of the adjoining plains. There is nothing to suggest that the depth of the valley-deposits ever much exceeded what we now find. The plains deposits never extended into the valleys of the Sátpúrá, some of the minor streams from which are still accumulating materials upon the deposits of the main valley. There are nowhere any signs of high-level deposits, along the borders of the basin, whether remnants of a former phase of denudation of the actual valley-formation, or (like the ossiferous gravels of Northern Europe) remnants of deposits formed in a more ancient shallower rock-valley. The ossiferous beds of the Narbadá seem to be simply a member of the last and only valley-deposits, which have now for a long period been undergoing denudation. But I know of nothing to suggest that the change from deposition to erosion supervened at a time much prior to the 'recent' of the geological scale.

The only debateable stratigraphical point upon which a stand might be made, is whether unconformity occurs, indicating a general and possibly a great interruption of deposition between the ossiferous beds exposed at or near the present level of the river channels and those above them. I have examined many sections with a view to testing this supposition, but I have failed to confirm it. One often finds local unconformity—coarse gravel upon a weathered surface of stiff clay; but these are no more than must occur in the normal process of formation of river deposits; and most frequently it is impossible to detect any break in the section. The fossils, moreover, occur largely in the gravels above this supposed unconformity, without any sufficient grounds for supposing them to have been washed out of the clays. Thus, then, there is nothing like a corresponding amount of evidence for work done here since the age of these bones, as there is in Europe for work done since the formation of the ossiferous gravels and cave-deposits; although the permanent staff of operatives is much more powerful in the former case. Every season there occurs in the Narbadá a rise of from 40 to 70 feet, with a stream of great force. It is, as I have said, impossible to make an exact comparison, on account of the undetected influences that may have been at work on either side to accelerate or to retard. I only wish to point out that there is no presumption, either palæontological or mechanical, that these Narbadá deposits are older than the late Pleistocene.

If we turn to the great Gangetic valley, the old alluvium of which Falconer ranked with the Narbadá beds, the physical arguments lead us to a like conclusion. Here we have not to deal with a rock-basin; and the conditions are more appreciable. In the upper part of its course the Ganges cuts a broad abrupt valley, 60 to 100 feet below the level of the adjoining plains. In the lower region of the plains the denudation has taken a wider sweep; the old alluvium has for the most part been removed, isolated remnants of it only being found; and those, at least towards the modern delta, are being enveloped in the encroaching deposit of its alluvium. On the whole, the features of denudation in the Ganges valley seem to imply that this action was brought about by the subsidence of a former delta of greater extent than the present one, not by an elevation of the mountain region. Along the upper edge of the plains, the minor mountain-streams are still massing deposits continuously over the old alluvium; and in some of these recent torrential accumulations a fossil Hindú village has been dug out. If we now turn to our comparisons, it is evident that the signs of change and of work done here are nothing like so great as that recorded of the Rhine and the Danube in their valleys within post glacial times. Or absolutely, even stretching to the utmost the legitimate assumption of comparative stability of conditions in India, we can hardly reduce our estimate of the necessary duty of such a river as the Ganges, during the period allowed by a minimum computation for the lapse of time since the glacial period of Europe, to the amount of work I have indicated. So that here again the opinion obtrudes itself, that these old ossiferous alluvial deposits are not more ancient than the late Pleistocene.

From the description given of the implement-bearing lateritic gravels of Southern India by my colleague Mr. R. Bruce Foote (Quar. Jour., Geol. Soc., London, Vol. XXIV, p. 484, 1868, and Mem. Geol. Surv., India, Vol. X, 1872), I should think they may be as old as the Narbadá gravels.

H. B. MEDLICOTT.

July, 1873.

The shells of the ossiferous deposits.—The shells Mr. Hacket has placed in my hands for determination are all of them species, known to occur in the ossiferous gravels of the Narbadá, a list of which is contained in the Memoirs of the Geological Survey of India, Vol. II, page 284. They are all of them in the mineral condition observable in the shells from these ossiferous beds, and some of them are embedded in the ordinary matrix of many of the fossils of the group, a gravel strongly cemented by lime.

The most numerous and characteristic shells are Uniones, of precisely the same species and varieties as those now living on the spot, and it may be incidentally added, that no molluscous species is known to be included in these ossiferous beds which is not now living in the valley, though many species now living, have not as yet been detected in the gravels, which is a fact not without interest when the revolution is considered which has been wrought among the vertebrata since the days of the Hexaprotodon and Tetraprotodon, which, with numerous other pachyderms, proboscidians, and ruminants, then roamed over Central India, and disputed with man for mastery in the primeval world.

Associated with the Uniones, occur also Bulimus pullus, Gray; Melania tuberculata, Müll.; Planorbis convexiusculus, B.; Lymnæa acuminata, Lam. (?); and a Corbicula, probably Corbicula Cor, Sow.

Three species of Unio occur in the collection, U. MARGINALIS, LAM.; U. CÆRULEUS, LEA; and U. CORRUGATUS, MULL., which last embraces four distinct races, usually classed as species by most authors, but which, after some study of the Indian forms of the group, I incline rather to treat as local and permanent races, thereby reducing within manageable and natural limits the crowd of shadowy species, with which the literature of the group is burdened.

U. MARGINALIS, *Lam.*

This species is not uncommon, but is not so finely developed in proportion, in the ossiferous gravels, as the others, neither does it seem to occur quite so well preserved, nor to obtain the same weight of valves as in the other species, in which respect it simply agrees with the same species now living, which never displays any considerable thickening or calcification, under any conditions, however favorable. A perfect example, not fully grown, measures—

Breadth	57	Mills.
* Length	29	
Thickness	19	

Allowing for slightly broken edges in the fossil, these proportions closely accord with the living shell which I give from Manbhoom—

Breadth	61	Mills.
Length	31	
Thickness	18	

A second specimen from these beds, which may be considered fully adult, measures 93 mills by 43.

U. CÆRULEUS, *Lea.*

This species attains to a superb development in the ossiferous gravels, and merits nominal recognition, since it does not quite correspond with any variety hitherto separated. It may stand as var. Namadicus, Theob.

Two perfect examples measure respectively—

	a.	*b.*	
Breadth	56	46	Mills.
Length	31	24	
Thickness	23	17	

A precisely similar form is now living in the Narbadá, and differs less, from the type of the species, than some other races in other parts of India do. It agrees generally in the form of the teeth, in shape, color, and sculpture, save that each character is heightened in the Narbadá form. The lateral teeth often display a carneous tinge, and the sculpture of the valves is not only stronger than in the type, but covers a far greater area, both on the valves and their posterior slope. A very similar form, though departing more from the type as regards shape, inhabits the Kistná valley, where it attains a breadth of 60 mills—(the type measuring only 43).

U. CORRUGATUS, *Müll.*

It is a great pity that the type of that species of Unio, which seems to unite the greatest number of races in India, should be so ill characterised, difficult of identification, and apparently, with a good series under view, so aberrant from the more strongly marked forms, which strict zoological argument requires should be united to it. On this subject I would

* Length is measured at right angles to a line tangential to the ventral margin.

refer to Mr. Blanford's contributions to Indian Malacology in the Journal As. Soc., Bengal, for 1866, page 134, which contain a highly useful and condensed paradigm of our Indian Uniones.

Mr. Blanford is undoubtedly correct in saying that "both Lamarck's and Chemnitz's types (of Corrugatus) are quite distinct from Benson's U. favidens, which has been confounded with them," but with a very large series before me, I consider that this distinction is a *racial* one, not a *specific* one.

If the rules of priority would have permitted it, I should have preferred, as the more natural course, to have taken Benson's U. favidens as the type of that species round which so many races or sub-species cluster; but as this cannot be, U. favidens must stand as a race perfectly separable, but still only a race of the wretched, ill-nourished U. corrugatus, Müll., for the epithet "*tenera*" applied to any of the forms of this robust species, stamps it as an abnormal individual, impoverished by unfavorable local conditions, and subjected to deficient or imperfect alimentation.

That the utmost diversity exists between the races which I unite under U. corrugatus may well be, since without pretending to anything like a complete knowledge of all the forms of this species throughout its entire Indian range, there must still be admitted sixteen separable races, exhibiting very variable degrees of difference from each other; even after excluding *U. lævirostris* of Benson as a synonym of *U. Nagporensis*, Lea, and uniting *Nagporensis*, Lea, with Wynegungensis, Lea, with which it is essentially identical, or too trivially distinct to be separated, judging from a large series of both forms.

U. CORRUGATUS, *Müll.*

1. Var. triembolus, B.

This form occurs very fine, both living and fossil, in the Narbadá.

A fossil specimen measures—

Breadth	66	Mills.
Length	40	
Thickness	26	

and I have no living specimen which quite attains these dimensions.

2. Var. Wynegungensis, Lea.

A stout trigonal and elongate form, which approaches the *U. lævirostris, B.*, seems equally common with the last, and passes into it.

A fossil specimen measures—

Breadth	73	Mills.
Length	39	
Thickness	27	

And in this case also I have no living specimen which equals these dimensions, my largest specimen of this type from the Kistná only reaching 60 mills.

3. Var. Indica, Sow.

This well marked form occurs both living and fossil; one of the last collected by Mr. Hacket measuring—

Breadth	30	Mills.
Length	27	
Thickness	19	

This is not a large race, as a fine recent specimen from the Narbadá only measures 41, 34, 21 mills. It is mainly confined to the Narbadá, though I have it also recorded from Rajputana.

4. Corrugatus, Müll.

The preceding forms pass into one, which in the young state closely approaches the type, save that it is a stouter shell.

There is, moreover, no fixity as regards the sculpture on the valves, so far as the extent covered by it, still the general facies is that of the type, which, according to Mr. Blanford, would seem more common in Southern India than in the Gangetic* basin. A fossil specimen measured—

Breadth	...	...	...	·27	Mills.
Length	...	...	...	20	
Thickness	...	...	...	12	

July, 1873. W. THEOBALD.

NOTE ON THE BARÁKARS (COAL-MEASURES) IN THE BEDDADANOLE FIELD, GODÁVARÍ DISTRICT, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

The question as to the existence of coal in the Godávarí District, and indeed in the Madras Presidency—for the area under consideration is the only known one of coal-bearing rocks in the British territory to the south of the Godávarí river—is still as full of obscurity as it was when I drew attention to the Beddadanole field last year. I have had, during this season, another opportunity of examining the ground most closely, but without success; and this search was so close that it does not seem possible that any outcrop of coal will ever be found by surface searching. Any further exploration must, therefore, be made by boring, and I am not without hope that coal may then be found.

2. The most important point, and in fact the only tangible one to be relied on, is that the rocks of the Beddadanole area are *Barákars;* that is, they belong to the lower member of the DAMÚDÁ SERIES, or the coal-bearing rocks of India. It is true that no seam of coal is visible, but this does not at all necessarily imply the non-existence of coal.

3. To try and show that coal may exist in this field, I shall compare it with other adjacent fields, *viz*., that to the north-west, on the Godávarí below Badrachellum; and the Singareny coal-field to the westward, in the Nizam's dominions. In the first of these, though it was reported by Colonel Haig to Mr. W. T. Blanford that coal was said to have been found down there, no coal was to be found at the place; indeed, the borings afterwards put down would seem to show that coal could not occur at the surface. At any rate, the rocks were seen to be DAMÚDÁS; and borings revealed seams of coal. These are, however, not of much extent on the British side of the river, though they are probably large enough on the Nizam's side, as I have since found that an outcrop of possibly the same beds shows at some twenty-five miles to the south-west.

4. As regards the Singareny coal-field, I can compare it more closely with that of Beddadanole, having likewise again visited it this season, when it is now being thoroughly examined by Mr. Heenan, the Superintendent in charge of the Nizam's coal-fields. The only difference of outward circumstances, as regards the present enquiry, between this and the Beddadanole field is, that coal did show at the surface in the former, though only in the most fortuitous way. Otherwise, the series of rocks (*Barákars*) in each field are identical

* For the information of Naturalists at home, I may as well add that the Narbadá does not belong to the Gangetic basin.

in every way, in their appearance, constitution, and mode of occurrence. There are plenty of outcrops of rock over this Singareny area where one might expect that seams of coal, if they existed, might appear at the surface; but such is not the case; there is only the one large "pot-hole" hollowed out in the low ridge of sandstones in the bed of the river with the seam of coal showing at the bottom. Nevertheless, since the borings have been put down by Mr. Heenan, not only has the first found seam been traced in other parts of the area, but three more have been struck, one above my seam and the others below. So that here we have a field with at least four seams of coal, the lowest found as yet being a very thick one, and having its strata so laid down that all these seams ought to crop out at the surface, whereas only one is just exposed. Outcrops of all the seams do probably exist; but, as would be likely, owing to the coal being cut into and washed out at these places by the weather and the streams, they are either now covered up by sand and débris gathered between the exposures of the harder beds, or are hidden by the settling down of superincumbent strata.

5. This concealment, or washing out of coal outcrops, may equally exist in the Beddadanole field, as, it is hardly necessary to state, there are numerous spaces in the nullahs between the exposed rock masses which are filled in with sand, though, as a general rule, the sandstones are very well and frequently exposed. Again, the lie or dip of the strata is very low, on the average about 5° to the westward, and they undulate to some extent; while the general surface of the area occupied by the *Barákars* is flat; and thus the sandstones have not been deeply cut into by the streams, so as to show enough of the strata.

6. There is, besides, a physical feature of this area which seems to hold out some hope that there may be hidden coal. The field is traversed by a river of from 50 to 60 feet in width, which flows in the direction of, or with the strike of the strata, or along the outcrop, that is, nearly north and south, a course which, viewed with the rest of its route over the *Kámthi* area, is somewhat exceptional. This course of the river may be due in part to the existence of a band of softer strata occurring between the sandstones which show at rare intervals on either side of the river. Indeed, I think there can be no doubt that there is a band or seam of softer or more easily worn strata covered up by the sandy bed of the river; or we should have had rock cropping up at places in the channel. But boring alone will tell whether coal seams occur in this soft and denuded bed.

7. The exposed area of *Barákars* is, unfortunately, not extensive, being only about 5½ square miles. It is covered up immediately on the western side of the field by the great series (*Kámthis*, of Blanford) of red and brown sandstones, in which there is no coal, constituting the upland country of Asharaopettah (Nizam's dominions) and Jeelagoomilly, &c., (British territory) to the westward. There must, however, be a good spread, equal in area at least to that exposed, of the *Barákars* hading down underneath the *Kámthis*. I am led to expect that this *infra* Kámthi extension is larger than I originally thought, on account of the westerly dip and the great thickness (about 300 feet at least) immediately under the covering edge of the *Kámthis*. Also, as we may judge to some extent by the lie of these last towards Jeelagoomilly, there is a roll up again of the beds towards that village, thus forming a synclinal or depressed curve of the strata, indicative of an ancient valley, over part of which the Beddadanole *Barákars* were deposited. This same valley beneath the *Kámthis* appears to have opened out south-eastwards, leading to the inference that if the *Barákars* do extend any distance underneath, they would lie down this valley, rather than up or across it, and so be still in the British territory.

8. An indication of the possibly large extension of the *Barákars* underneath the *Kámthis* is shown some miles to the north-west; for, as already stated, I have lately found what certainly appear to be *Barákars* cropping out on the western edge of the great

Ellore-to-Badrachellum spread of *Kámthis* at a point some twenty-five miles south-west of the coal-field below Badrachellum, and which may be an extension of that field.

9. To summarise, I think it may be concluded—

1st.—That there is a likelihood of coal from the fact that the sandstones of Beddadanole are of the *Barákar* group.

2nd.—That there is some slight reason for suspecting that the Beddadanole river bed conceals coal outcrops.

3rd.—There is every expectation of the area, exposed and hidden, of the *Barákars* being at least ten square miles in extent, if not a great deal more, and that it lies in the British territory.

So that, should it be decided to try the field by boring, and I would most earnestly recommend this proceeding on account of the above three conclusions, though they be laden with conjecture, the crucial bore holes ought to be put down near the right or western bank of the stream, where they will run to a depth of over 200 feet before the coal-bearing strata are pierced. One bore-hole at about half-way down the course of the river within the field would be almost sure to strike coal if there be any in the field; though, even if this failed, another might be struck down about three-quarters of a mile further west, as the first bore-hole would only have pierced about half the thickness of the exposed field.

Details as to the character of the rocks, their lie, and the size and position of the field have been already given in the Records of the Geological Survey of India, Vol. V, part 4, 1872.

CAMP, GODÁVARÍ DISTRICT, } WILLIAM KING.

April 18*th*, 1873.

NOTES FROM A PROGRESS REPORT ON THE GEOLOGY OF PARTS OF THE UPPER PUNJAB, *by* A. B. WYNNE, F. G. S., *Geological Survey of India.*

The first two seasons during which the operations of the Geological Survey were extended to the Punjab having been devoted to the examination of the Salt-Range, the following one was, by order, chiefly spent in rapidly reconnoitering the country surrounding the upper plains of the Punjab, both on this side and, as far as possible, trans-Indus, in order to obtain a preliminary general knowledge of the complex geological features presented.

At its close lines of observation were carried through the Hazara district, and a closer examination was made of the Sir Ban mountain region, close to Abbottabád, which was found to afford an epitome of much of the geology of the Upper Punjab (see Memoirs Geological Survey, Vol. IX, Art. 3.)

At the commencement of the succeeding season, that of 1872-73, the detailed working of the one-inch maps of the Rawul Pindi district was taken up and carried on with one interruption, during which the Salt-Range was again visited, in order to obtain a special collection of its mineral products for the Vienna Exhibition of 1873.

With the valuable assistance of Dr. Warth, Deputy Collector at the Mayo Mines near Pind Dadun Khan, a series of specimens of several maunds in weight was formed and despatched to Calcutta. This included a block of rock-salt cut purposely from the mine, about two tons in weight; and amongst the others, a complete series of large specimens illustrating the geological structure of the part of the range overlooking Pind Dadun Khan,; besides several specimens of newly found minerals from the Mayo Mines, such as Glauberite and Kieserite, varieties of pure potash salts, and others in combination with sulphates.

Specimens of the cubical salt of Kalabagh, the alum shale, gypsum containing quartz-crystals, and gold sand from this latter locality, were also added to the collection with the help of Mr. Wright, Collector of the Salt Revenue, and Dr. Warth.

At the same time efforts were made to obtain a block of trans-Indus salt from the mines of Bahadur Khel, which resulted in the addition of a 27-maund block of this salt to the collection forwarded by Captain Plowden, Assistant Commissioner at Kohat.

These two large specimens show the marked difference of colour between the clear white or reddish salt of the Salt-Range and the gray or dark-coloured trans-Indus salt.

It was during the progress of the Vienna collection at the Mayo Mines that the discovery of the potash salts was made, attention being called to their situation in the mines by the hardness of part of a band of 'Kullur' or impure salt through which a drift was being excavated. On examination of this, the band of potash salts was found to be 6 feet thick, partly pure and partly mixed (sulphates, &c.); but its further extension could not be at the time ascertained owing to its situation, while there was little or nothing in the general appearance of the potash mineral to distinguish it from the ordinary salt. Specimens were immediately subjected to a preliminary analysis by Dr. Warth, but the crystallography of the new found salts was a subject unapproachable for want of proper instruments for measurement. It is hoped that some of the perishable crystals put up in glass bottles may have reached Vienna in a state fit for examination.

The deposit will probably prove interesting, as the only one known within British possessions, and may become very valuable should the importation of these high priced salts into England from the Continent be interrupted. Dr. Warth suggests that it may eventually be found advantageous to work this deposit for the alum factories at Kalabagh. For shipment from India the transport of the salts would present no great difficulty by the wire-tramway from the mines to the banks of the Jhelam, and thence by water to Kotlee on the lower Indus or to Kurrachee.

In carrying out the detailed examination of the Rawul-Pindi district eastward of that station, the hills were found to exhibit the relations of the "sandstone and clay" portion of the great outer tertiary belt, well known as the southern border formation of the geological system of the Himalayas. Here the lower, red, or Murree (or Subathu), beds pass upwards by alternations of red clays or shales and gray sandstones (locally distinguished by the Punjab survey-party as the "red and gray" series) into softer gray sandstones with clays of a more orange colour, the highest beds being a thick group of incoherent conglomerate rocks, previously known to exist on the Indus and at both ends of the Salt-Range proper, as well as in some other places. In the generality of cases this conglomerate group was found to present a gentle transition from the lower beds upwards; the pebbles, chiefly of crystalline rocks, after their first appearance increasing in number and size till the whole rock becomes a mass of small boulders or large pebbles slightly held together by an inconsiderable calcareous matrix. The rock is seldom found hard enough to show its own outcrop, and presents the greatest difficulty in discovering clear sections, though hills formed of it possess in their undulating pebbly surfaces a characteristic by which the conglomerate can be recognised from long distances.

Associated with this conglomerate group, and indeed throughout the whole of the arenaceous and argillaceous portion of the tertiary rocks of this country, are various beds, usually calcareous sandstone, conglomeratic sandstone, or a peculiar finely concretionary calcareous and earthy or sandy rock of a gravelly pseudo-conglomeratic appearance, often containing more or less numerously fragments of bones. In the upper and more conglomeratic portions of the series, these bones are frequently mammalian; while below, even to the base, and there associated with Nummulitic, or *Rotalina*-bearing, layers, the bones, rarely in a good state of preservation, are believed to be more commonly reptilian, as appears from Major Vicary's writings to be the case in the corresponding beds at Subathu.*

From Murree† southwards the general stratigraphical structure of the hill country is a succession of great waves commencing with an anticlinal curvature close to that station, the synclinals of the curves embracing some of the higher strata, form grand vertical cliffs, when largely composed of massive sandstones bedded nearly horizontally, as around the elevations of Karor and Nurr'h, very similar to the cliffs on the Indus at Dangote above Kálabagh.

Towards Jhelam the curves appear to become softer and more open, and some of the highest beds, the conglomerates previously mentioned, come in.

In the vicinity of Murree, and along deeply excavated valleys lying in a general direction north of east and south of west, overlooked by the northern slopes of the Murree ridge, the lower red tertiary rocks terminate; one side of these valleys being chiefly formed of the red rocks, and the other of contorted limestones and shales, towards which the Murree beds are frequently inclined. These are the main or striking circumstances of the positions of the rocks, which, however, when examined in more detail, are not found to be strictly limited to opposite sides of the valleys, small portions of the red beds being found in the limestone hill slopes, and a pretty constant rib of nummulitic limestone stretching from the Kooldunna hole (lying northwards from Murree) along the foot of the Murree ridge westwards by south.

The rocks on both sides of the junction-valley present the strongest evidence of disturbance; and faults, or lines of displacement, are numerous. Starting from Murree, red and grayish sandstones, with imperfect plant-impressions alternating with deep red clays, form all the slopes in a descending northerly direction, till the rib of limestone is reached. On both sides of this, calcareous nummulitic layers alternate with the red beds. And gypsum occurs more or less on the Murree side of the rib and close to it. Beyond the rib of strong dark limestone, red and gray sandstone and clay beds (forming the major portion of Kooldunna hill) predominate; and on the ascent of the opposite slopes of the Mochpoora chain, gray nummulitic limestone, sometimes crowded with small *Rotalinæ*, alternate with dark shales. But even here detached longitudinal masses of the red Murree beds lying parallel with the principal features appear to be faulted deeply into the limestone group. Further up on the Mochpoora ridge and beyond it, northwards, jurassic and triassic rocks appear, in the manner shown in Dr. Waagen's paper on the neighbourhood of Khairagully and Chumba Peak (the result of a joint examination of the locality with the writer, see Records Geological Survey, Vol. V, page 15).

In studying the junction of the more mechanically formed tertiary beds with those consisting largely of nummulitic limestone along the Murree valleys but little value can be attached to the distorted dips of the beds; some traces of a former regular succession from the limestones of the Mochpoora ridge upwards into the Murree beds being perhaps slightly indicated; and the present positions of the rocks may be, for all that is seen to the contrary, freely and fairly attributed to the united results of folding and faulting; traces of the latter being too prevalent for faulted displacement to be excluded from consideration in the effort to account for the existing state of things.

Beyond the Murree region westward, the junction of the Murree rocks with the limestones to the north presents very much the same general character, the gypseous zone being

* Quar. Jour. Geol. Soc., London, Vol. IX, p. 72, 1853.

† Koh Marl (*i. e.*, Marl mountain) is the name of this locality, the a having the sound of ŭ; hence the adoption here of the common phonetic and more popular spelling.

traceable at intervals in the position first described. The outer limestone rib expands and is flanked by another similar band, the alternation of limestones and Murree bed being apparently produced by faults; at least it has entirely this aspect in the neighbourhood of Shah Durah.

Further west a strongly marked line, also bearing the strongest resemblance to a fault, diverges north of Rawul Pindi from the main line of junction in the direction of the Margulla pass, on the Peshawur road. Along it the Murree beds are brought against the hill limestones, here including both nummulitic and jurassic rocks (with perhaps an intervening cretaceous band). The jurassic beds contain a very marked layer made up of large *Trigoniæ* resembling *Trigonia Ventricosa*, Kraus, with some smaller forms; while beyond Margulla *Ammonites* and *Belemnites* are also to be found. As usual along the contact of the limestones and finely detrital rocks, the red Murree beds are often either vertical or highly inclined towards the limestones. The actual junction surface, from being situated at the foot of the hills, is concealed; and the branch line disappears beyond Margulla, the low ground in that direction being heavily covered with detrital deposits, and the small hills in which the spur from Mochpoora terminates being formed of the nummulitic and jurassic limestones, shales, &c.

The main line of boundary between the limestones and the Murree group continues from the place of divergence north of Rawul Pindi westwards, marked at first by low limestone hills at the foot of the Mochpoora ridge or spur, which gradually increase in height and width, till they form the chain of the Chita Pahar mountains, abutting on the Indus several miles southward of Attock, near Nilab Gâsh. Beyond this the same feature continues westward along the Affreedi hills passing just north of Kohat; on this line also the gypseous zone seen at Murree and more largely developed at Tret, as well as lower down in the plains, may be recognised at intervals. In connexion with this gypseous zone, and sometimes in the gypsum itself, are sulphurous springs, which bring petroleum or mineral oil to the surface; this also frequently occurs slightly impregnating the adjacent limestones.

Along the whole of this line of junction within British territory, from near the Jhelam* to the Indus and beyond it, *the positions* of the two sets of rocks furnish nothing decisive in the way of evidence to prove which is the older: and in many places the inference from dips would be directly contrary to fact. The nummulitic limestones of the hills being, however, found in some spots close to the boundary passing downwards into jurassic rocks (with or without a thin intervening band which may be, but is not here proved cretaceous), all doubt of the true position of the red rocks is removed; and their close association with certain layers containing nummulites on the south side of the junction fixes their age with certainty.

It will then appear that on one side of the general boundary there are red Murree beds containing layers of nummulitic, calcareous, or earthy rock, while on the other there is a mass of limestones and shales of nummulitic, jurassic, and perhaps some of cretaceous age. The junction itself presents all the features of a fault or band of several faults, and the only reason why it should not be unreservedly accepted as such is that, in the Simla Outer-Himalaya examined by Mr. Medlicott, the same tertiary sandstones and clays as occur in this country have been divided by that gentleman into groups, the boundaries of which, having the same general resemblance to lines of fault, are in most cases believed and in some are proved by him to be lines of unconformable contact and not of faulting (see Memoirs, Geological Survey, Vol. III).

* The continuation of this line in the valley of the Jhelam has been recently seen. It makes a sharp bend northwards near Kohala, and runs along the foot of the Mochpoora and Huzar hills on the right bank of that river, crossing the bend of the stream near Mozufferabad in Cashmere. Here it bends to south-east, following the course of the Jhelam still on the right bank, but far up on the flanks of the Kyj Nag range to Ooree, where it crosses the river and takes a course along the outer flank of the Peer Punjal chain. Slates, metamorphic rocks, and occasionally limestones, are seen in junction with the red Murree rocks, the line still resembling one of faulting.

There can be little or no doubt that the red Murree rocks are, or represent, the nummulitic Subathu beds of Mr. Medlicott, which, in the Simla districts, rest unconformably upon limestones and slates of unknown age; while in this part of the Punjab nummulitic rocks occur on both sides of the junction. It would be manifestly improper to ignore this line of junction and carry the nummulitic boundary across it while it presents so marked a feature. Without some palpable local evidence, it would be equally improper to indicate an unconformable break in the nummulitic series; but as this might possibly exist together with the faulting and displacement which seems to have occurred, it is proposed to express the line upon the map as one of fault, at least provisionally or until the whole country has been explored, with the hope that something further may be found to explain the difference between the present aspect of the junctions here and in the Simla regions.

With respect to the other junctions of Mr. Medlicott, showing repeated unconformity in the ascending series between his tertiary sub-groups, the difference in this district has to be noticed. The description of the rocks would point to their close identity; but in the Simla region the succession appears to have been interrupted; while here the most apparently regular sequence and conformity has only been observed southward from the limestone hills, crossing the country in an east and west direction north of Rawul Pindi; the red Murree rocks, either vertical or dipping at high angles, reach down to the latitude of that place, interrupted only by a long ridge of nummulitic limestone of the hill type, which, lying west by south from the station, appears to occupy a space between two converging lines of fault. Southward of this the Murree beds pass up (still retaining their high dip) into the 'red and gray' series in which the first bands of conglomerate appear. In these conglomerates, notwithstanding the parallelism of the beds, are enclosed limestone pebbles, proved by the small *Nummulites* which they contain to have belonged to that formation; but where the break occurs during which the denudation of the older rock took place it is at present impossible to say.

Above the 'red and gray' rocks come others with more of orange colour in the clays; and these pass up, as already stated, into the conglomerate group. The upper portion of the series in the neighbourhood of these comglomerates has been identified from its fossil bones with the Sivalik group by the late Dr. Falconer (paper by Mr. Theobald on the Salt-Range: Proceedings, Asiatic Society, Vol. XXIII, 1854, page 677). So that in this district the Subathu and Sivalik groups of the Simla region may be considered present; while many of the intervening rocks would answer to the description of the Nahun beds of Mr. Medlicott. The peculiarity of the frequently interrupted succession in that region, contrasted with that almost complete sequence here, would indicate considerable difference in the physical causes which affected the deposition of the tertiary rocks in one region as compared with the other.

It is difficult to estimate the thickness of these sandy and earthy tertiary rocks in consequence of the numerous contortions, and the all but positive certainty that in many places, where the beds are apparently steady at high angles or vertical, the arches of numerous folds are concealed. The fact of this contortion impressed Mr. Lyman (Report on the oil regions of the Punjab) with the idea that the thickness of the whole was much less than it would appear. But while it is of course possible, it is at the same time not easy to imagine, all these contortions lying exactly so that the plane (or approximation thereto) of the surface of the country should intersect them without exposing either recognisable repetitions of each group or some of the next underlying strata. The absence of these cases seemed to point to an enormous accumulation of the beds, notwithstanding their convolution; and this is rendered more probable from an observation lately made in the Jhelam valley within Cashmere territory, where part of the red Murree group, dipping regularly at an angle of 45°, was estimated to have a thickness, on the flanks of the Kyj Nag range, of about one and a half miles. The dip in this case also was (obliquely) towards the adjacent older rocks.

Besides the tertiary conglomerates previously described, there is another very extensive group of more recent age, the pebbles in which are largely composed of limestone; it is very well developed about Rawul Pindi, and spreads unconformably over great tracts of the country, alternating with drab or pale pink or red or purple brick-clays, and frequently associated with calcareous tufa or calcareous conglomeratic solid massive beds called by the natives '*Koonjoor*.' The basal part of this group in immediate contact with the tertiary sandstones is often formed of strong beds of calcareous tufa or travertin.

These conglomerate and clay rocks are at present considered lacustrine, or formed by wandering river action; and their boundaries, if shown upon the maps, will be extremely intricate, as they are often cut through by the nullahs exposing the rocks beneath.

The superficial covering of the country is largely derived from the clays of this group; and where clays, shales, and such soft rocks abound, there is no lack of material to form a frequently thick deposit, the result of atmospheric action.

SRINUGGUR,
Cashmere, May 25th, 1873.

A. B. WYNNE.

COAL IN INDIA, BY THEO. W. H. HUGHES, C. E., F. G. S., *Associate, Royal School of Mines.*

I trust it will not be uninteresting to the readers of the Records of the Geological Survey to have placed before them a few brief remarks which will tend to widen the scope of their knowledge with respect to our Indian coal-fields, and enable them, when the subject of coal is discussed, to uphold the claim which India enjoys to rank amongst the great coal-bearing areas of the world. It will doubtless surprise many to learn that both in the superficial extent of its coal measures and associated rocks, and in the actual amount of its coal, India is surpassed by few countries; and that with respect to the size of some of its seams it stands pre-eminent in the literature of mining.

Even that land of monstrosities and natural wonders, the United States of America, can exhibit nothing to compare with the gigantic seams of the Hengír and Damúdá coal-fields, some of which are one hundred and sixty, one hundred and twenty, and a hundred feet thick. These figures of course do not imply that there is this amount of pure coal; the term seam is used in its technical sense, as embracing the whole sum of coal and partings in a given bed.

Until within the last few years the information regarding our coal-fields was scanty and imperfect; but of late, the action of Government and the labours of the Geological Survey have been more in accord with the requirements of the country; and the result is that, although our data are still far from being complete, yet we can form an approximate estimate (which may be accepted as a nucleus for future computations) of the area of our probable coal supplies, their geographical position, and the quality of fuel which they can yield.

And in the first place with regard to our probable coal supplies, it becomes more and more important, in the face of the steadily increasing price of English coal, to enquire whether India will be able to furnish the fuel so essential to the further development of those industries which the energies of Englishmen have in some instances created and in other cases fostered to a maturer growth. In answer to this question, around which centres the chief interest in this article, I think it will be sufficient if the reader glance at the subjoined table of areas to feel satisfied on this point.

The same method of calculation has been acted upon in regard to India, in the determination of the superficial extent of its coal-bearing areas as that applied to other countries, and the length and breadth of the tracts over which coal rocks *may be presumed* to extend have been multiplied to give the number of square miles.

Taking the coal-fields already partially and in whole examined, and allowing for the unsurveyed portions of Central India, Assam, Burmah, and the Tenasserim province, &c., we may safely assume 35,000 square miles as being within the mark.

In order to show how these figures are arrived at, I append the following table. Besides, however, enumerating the different Indian areas, I have added a list of such countries the areas of which I have been able to compile from various sources of reference; and I have also noted the countries in which coal is known to occur, but concerning which there is no knowledge of the extent of their coal measures. By thus enlargening the table, I hope its usefulness for the purpose of comparison will be increased:—

Table of Areas.

Name of country.	Area in square miles over which coal-rocks may be presumed to extend.	REMARKS.
India	35,000	*This mileage is made up as follows*:— Godávarí area (including its affluents) ... ... 11,000 Son ... ... 8,000 Sirgújáh and Gangpúr area ... ... 4,600 Assam ... ... 3,000 Narbadá area (including its affluents) ... ... 3,500 Damúdá... ... ... 2,000 Rájmahál area ... ... 300 Unsurveyed and uncomputed areas ... ... 2,700 Square miles ... 35,000
United States	500,000	The productive area of coal is much less. Professor Hitchcock estimates the area of the true carboniferous system at 230,659 square miles.
China	400,000	This estimate is not thoroughly reliable, but it is certain that there is an enormous coal-bearing area in China.
Australia	240,000	In New South Wales, the coal area is said to be 120,000 square miles. In Queensland the same area is supposed to exist.
Russia	150,000	This area is probably far below the real extent of the Russian coal-formation.
India	35,000	
British America	18,000	
Great Britain	12,000	Mr. Hull gives 5,431 square miles as being stored with coal to a depth of 4,000 feet.
Spain	8,000	This estimate is vague. Some authorities give 4,000 square miles, and others 2,000.
Japan	6,000	
Germany	3,000	By Germany is meant all the German-speaking provinces, except those under Austrian rule.
France	2,400	
Austria	2,000	Some of the Austrian brown coal seams approach the Indian seams in thickness.
Belgium	520	
Trinidad	318	

Borneo	The coal of Labuan is reported to be of good quality, and very fair coal occurs in the Sarawak territory.
Brazil	There are large coal-fields in this splendid country.
Cape Colonies	There is coal in this as in so many other dependencies of the English crown.
Denmark	Only a small quantity of coal is raised in the island of Bornholm.
Falkland Islands	These islands contain coal.
Greece	Lignites have been worked at Koumi.
New Granada	The coal of this country is said to be cretaceous.
New Zealand	The calculated amount of coal in New Zealand is four thousand millions of tons.
Persia	A large area of coal is stated to occur.
Portugal	A small coal-field exists near the mouth of the Douro.
Zambesi	This coal was brought to light by Livingstone.
Zanzibar	Some coal, said to be Zanzibar coal, was analysed by Mr. Tween, of the Geological Survey, and gave— Carbon ... ... 42·4 Volatile matter ... 30·4 (moisture 4 per cent.) Ash ... ... 27·2 100·0

The geographical positions of most of our fields have been already indicated in the "Coal Resources of India" compiled by Dr. Oldham and published in 1867. It was pointed out in that work that a chain of coal-fields extended across India from near Calcutta to the Haidrabád Assigned Districts (the Berars), lying within the 20° and 25° parallels of north latitude; that other fields occurred in the valley of the Godávarí and its affluents, and that throughout Assam, Burmah, and the Tenasserim province there were deposits of coal.

Some of these fields lie in the route of direct railway communication between Bombay and Calcutta, and of course would prove useful sources whence to draw fuel. But the geographical positions of others again are such that they will probably not answer any useful purpose for many years to come.

The quality of Indian coal is usually denoted by the adjective *bad*, but I believe this word has been too freely used. The average of Indian coal is certainly inferior to that of English; but there are many seams in the Ráníganj field, and more notably one or two in the Karharbári field, which yield very good coal indeed. Much of the Assam coal is said to be excellent. And it is justifiable to entertain the idea that if our fields had been more extensively opened out and worked to a greater depth, coals would have been met with of a quality sufficiently good to make us cautious in regard to the indiscriminate use of the word bad. Several attempts have of late been made on one of the short lines of the north of England to burn inferior coals in the locomotive engines; and I have been informed by a gentleman personally interested in the matter that the experiment in which he was concerned proved very successful. The principal modifications of existing arrangements are, I believe, in connection with the grate and draught, but there are minor ones with which I am not acquainted. Nearly the same amount of work, it is stated, was done by the inferior coal as is at present done by the best locomotive coal. How important these practical experiments are in respect to India no one will deny, and I hope the day is not far distant when we shall profit by them.

CHANDAH,
1st January 1873.

On the Salt-springs of Pegu, *by* William Theobald, *Geological Survey of India.*

Prior to the occupation of Pegu by the British, a considerable manufacture of salt was carried on inland, from the somewhat feeble brine springs, which are so plentifully distributed throughout a large portion of the valley of the Irrawadi, more particularly along the eastern skirts of the Arakan range in the districts of Myanoung and Henzadah. Of late years, this manufacture has to a great extent ceased, and is now merely practised on a very reduced scale at a few spots, to supply strictly local requirements. The decay of this industry arises from the abundant supply of the article, now procurable, manufactured in the delta* from sea-water; and we may expect this sea-salt entirely to supplant that manufactured from the springs, as the system of traffic and barter, by means of itinerant traders, enlarges more and more, and the facilities for obtaining the cheaper article become greater, and, therefore, more appreciated. Even now, many spots are pointed out, from which salt was formerly obtained, but at which the precise locality of the wells, long since fallen in, has been forgotten, and every year makes it more difficult to gather information on this point, as the action of the seasons and the growth of vegetation combine to efface all traces of former workings. In some places skirting the hills, the plough now passes over ground where salt-wells formerly existed; and hence it is mainly in the localities where massive timbering was employed to support the sides of the wells that we can best judge of the number and importance of the old workings.

The wells vary in shape, being either round or square, usually the latter, from the greater facility of timbering the sides; whilst some are little better than rude excavations or enlargements of an original cavity, sufficient to permit the accumulation of the brine for convenient removal. Others again are sunk 10, 20, or 30 feet, and have their sides roughly, though effectively, supported by stout planks. In some instances (*e. g.*, Hlahndeng and Kadeng-mah-ngo), these planked wells are sunk to a small depth in the bed of a stream, and during the monsoon become filled with sand, gravel, and fresh-water, but on the season for active operations commencing in the cold weather or towards its close, it was customary to clear them out, when the brine would be found, occupying its own place, a short distance below the ordinary level of the bed of the stream.

The strength of the brine is variable, being often only feebly saline. This probably depends on admixture with surface water, as the strongest noted was yielded by the Sadwingyee spring, which was also most copious, and consequently the least obnoxious to admixture with surface water, which may be supposed often to affect the more feeble and sluggish springs. I may here remark that, though usually spoken of as brine *springs*, these springs are, in the great majority of instances, hardly entitled to the designation, having scarcely any flow. In the case of Sadwingyee, there is a copious spring. In the case of Nummayahn and Sahngyee there is a perceptible flow, and no more, accompanied by a somewhat copious evolution of marsh-gas, which keeps the pools turbid and in a state of constant ebullition. The more usual mode of occurrence of the brine, is among crushed or disturbed strata, especially harsh dark shales, in which the brine occupies cracks and pockets, and, on a well being sunk therein, trickles into it from the surrounding strata, but without causing an overflow. Mr. W. T. Blanford, in a memorandum on the salt-wells of the district of Henzadah (May 1st, 1861), points out thirteen different localities, the richest being that at Sadwingyee, which indeed may be regarded as the richest in the province, and of which I here quote his account.

"The appended list specifies thirteen† different localities in the district of Henzadah at which salt is known to have been worked. Of these, only three were at work at the time

* Imported English salt is now competing with the country-made article.

† Nos. 63 to 69, 71 to 74, 79.

of my visit, the principal of which was Sadwingyee, the spring at which place is probably one of the most productive yet known in the region. The flow of water in the well was carefully measured by my fellow assistant, Mr. Fedden, and found to be 57·15 gallons per hour, or about 1,370 in the 24 hours. By a rough experiment the water was found to contain 4,704 grains of salt to the gallon, so that the quantity of salt daily yielded by this spring amounts to 920 lbs. avoirdupois, or 8 cwts. 24 lbs.

"Few springs probably yield so largely as Sadwingyee, but it was not found practicable to ascertain the quantity procurable from any other. The water is so salt that it can be evaporated at once without previous partial evaporation by the sun. It is boiled down in large iron pans, placed in twos or threes, over an earthen fire-place, the method being somewhat similar to that employed in India for evaporating the juice of the sugarcane."

The pans mentioned in the above paragraph are shallow, extremely thin cast-iron pans, of English manufacture, of about 30 inches in diameter, and principally used in the preparation of the common 'jaggery' or unrefined sugar from the juice of the 'date,' 'fan,' or other palms. Earthen pots are also used for concentrating the brine, of an oval shape, with sides nearly an inch in thickness, and capable of holding between 3 and 4 gallons. In the delta, where salt is habitually made from sea-water, a somewhat different arrangement is adopted. A circular oven of brick is constructed, something like a large bee-hive, with holes at intervals to receive the oval earthen pots above described, to the number, perhaps, of as many as sixty in one oven, the ultimate concentration being, I believe, in the ordinary shallow iron pans, though this is probably a recent innovation.

The distribution of these springs is as follows:—Of 79 localities recorded in the accompanying table, 21 are situated within the area occupied by the newer tertiary strata of the province, of miocene age; 9 within the much narrower belt of country formed of unaltered, and comparatively slightly disturbed, nummulitic rocks; whilst most of the remaining 49 localities form a conspicuous band along the outer hills, on the eastern side of the Arakan range, among altered rocks, grouped comprehensively under the term Negrais beds, of, in part possibly, nummulitic age likewise.

No salt springs are known to me on the western side of the Arakan range, or on the eastern side of the Pegu range. The whole are, as far as is at present known, confined to the Irrawadi valley; though future exploration may possibly show that this remark only holds good within the area to which it more immediately relates.

The most easterly springs are those of Kadeng-mah-ngo and Pyeng-mah-choung, fifty miles to the south of the former, distant, respectively, sixty-seven and seventy miles from the Arakan range, and thirteen and eleven from the Pegu range, measured at right angles to their general direction. Seven miles south of the Pyeng-mah-choung springs occurs the spring of Toung-ngo, rising on the same north by west line of strike, and being accompanied by a copious evolution of marsh-gas. The Toung-ngo spring rises on a line of disturbance, as shown by the crushed and indurated character of the sandstones in its vicinity, and the lesser frequency of springs along this most easterly line of their occurrence may be partly attributed to the greater thickness of the newer strata, which they would here require to pierce before reaching the surface; and, partly, to their presence not having been so sedulously sought after by the natives, owing to the lesser demand for salt at such a distance from the river or lakes, yielding the great bulk of the fish from which the national gna-pee or fish-paste is prepared. Hlahndeng spring probably belongs to the same system, though situated a little off the direct line on which the others rise.

The second line of springs is that of which Nummayshn is the most important, and runs in a direction north by west, distant, respectively, thirty-two and forty-six miles from the Arakan and Pegu ranges. The On-nay-da-gyee spring near the frontier lies almost exactly on this line, which, if considered as one line, measuring from On-nay-da-gyee to Waddau-tha, is sixty-three miles in length, with a general coincidence of direction with the hill ranges bounding the valley.

On this line likewise is situated the spot known as Naht-mi or "the spirits fire," thirty miles north by west from Nummayahn, and which is merely a spot in the jungle from which marsh-gas issues through cracks in the soil, and becomes, from time to time, either intentionally ignited or accidentally during the prevalence of jungle fires. Above Nummayahn, in the river bed, there is considerable disturbance, as evinced by vertical strata, and it seems probable that all the springs of this group rise along one and the same line of fracture, probably a highly contorted anticlinal, though this may not be indicated by the appearance of the rocks at the surface, at the actual point of issue of the springs, which may mainly depend on local conditions, surface arrangement, denudation, and the like.

A little west of this line occur other springs (Nos. 8, 21, 9), which may or may not issue primarily along the same subterranean line of disturbance or fracture; but this is neither material nor possible to say.

Associated with this system of springs may be classed the Boolay, Laymyoung, and Tayzahn springs. The Boolay springs were simple wells sunk in sandstone at the mouth of the Boolay stream, but which have been long disused. The Laymyoung spring rises on the top of a low ridge forming mud pools from which a little marsh-gas escapes, much after the fashion of the Nummayahn springs, only much more feebly. Near the mouth of the Boolay stream, above where the road crosses, and close to the village of Kwonboolay, occurs the only hot spring known to me in Pegu, but it rises in the bed of the river, so that its temperature cannot be well ascertained, and sometimes it is entirely concealed beneath the sand.

The third line of springs is by far the most important, embracing probably several closely arranged parallel lines; and if we assume the Sahngi spring on the frontier to belong to this group, this line would seem to follow a curve, generally corresponding with that followed by the Arakan range. The Sahngi and Day-beng springs are situated in a line thirty-four miles long, with a general bearing north-west by north, with the Lengbhan and Shuagyeing springs a little on either side of it, and distant seventeen miles from the Arakan range. From Day-beng to Shah-si-bo the line is forty-two miles, with a bearing north by west, distant fourteen miles from the Arakan range, and marked by a perfect belt of salt springs. From Shah-si-bo southwards, the springs are rather more scattered, and run in a direction almost due south, the most southerly one recorded, No. 79, being one hundred and twenty-four miles in a straight line from the frontier spring of Sahngi.

This rich belt of springs is situated among a group of harsh dark indurated shales and sandstones; the induration being variable in amount, and never approaching metamorphism, properly so called, within the area immediately adjacent to the salt springs in question. Few or no fossils have been found in these rocks, certainly not within the above area, but their relation to the unaltered rocks of the district lends support to the view of their being possibly of nummulitic age.

In view, then, of the occurrence of these springs most numerously along lines corresponding to the general strike of the beds of the district, and of the direction, moreover, of the twin ranges which bound the Irrawadi valley; and having regard to the indications of compression and violent disturbance which the rocks in their vicinity often display; in view, too, of the association with them, on the same lines of strike, of the only hot spring in the province, and of spots whence issue both petroleum and marsh-gas, we may fairly assume that they rise along widely extended lines of disturbance, (anticlinal fissures most probably,) from the lower beds of the nummulitic or some still older group.

It may here be remarked that whereas the only known petroleum localities lie within the area of unaltered nummulitic strata, or of the newer Tertiaries, yet the greater number of salt springs lie below this horizon among the altered and presumedly lower members of the same group; a point which, if definitely established, as it seems to be, as far as regards the area hitherto subjected to examination, will not be without an important practical bearing in searching for petroleum, inasmuch as there is an idea prevalent that the presence of brine springs in this region is *per se* indicative of the existence below of the more valuable mineral. Having regard to the circumstances under which the mineral oils occur in America, there is nothing unreasonable in the supposition of a similar connexion existing between the brine springs and oil in Pegu, as is found in the new world—an idea strengthened, moreover, by the existence in the same districts of both oil and brine; but, as I have already pointed out, there seems no good reason for believing that, in Pegu, the same connexion between brine springs and oil exists as in the American oil-fields. On the contrary, it would seem that the reverse of what occurs in America is to be anticipated here. In America the connexion between the oil and brine is an established fact; the first petroleum obtained by boring having been accidentally obtained in 1819 "in sinking wells for salt in the little Maskingum river in Ohio," (Erni, "Coal-oil and Petroleum.") In Pegu, it would seem as though, if in sinking a bore, a copious brine spring were struck, this would probably indicate that the boring had penetrated to a horizon below that wherein the mineral oil was produced. In Pegu, as in America, the oil may rise to the surface with the brine, as the horizon of the napthagenic beds is higher than the sources of the brine, which is not the case in the American oil-field. But the non-association of the two in Pegu may, I think, be legitimately inferred from the fact of no indications of petroleum being known within the belt of rocks wherein the most numerous brine springs rise, as would hardly fail to be the case were the origin of the brine and petroleum in one and the same group of beds. That the co-existence, too, of brine springs and petroleum in Pegu is rather a fortuitous than a connected phenomenon (as it would seem to be in America,) is to some extent borne out by the fact of petroleum occurring in the Punjab in connexion with rocks of the same geological age as in Pegu, but without the accompaniment of brine springs, as in that province; so that our present experience may be summed up with the assertion, that whilst a copious dischaṛge of brine and marsh-gas may not be without value in determining a site for sinking for petroleum, in ground occupied by rocks of the upper portion of the nummulitic group or any rocks above that horizon, yet the same indications are not to be relied on as of equal promise, within the area occupied by rocks lower in the series, or of greater geological age.

It only remains to add a few words explanatory of my classing these altered or hill rocks as 'Negrais beds,' or possibly nummulitic in part, after having, in my recent paper on the 'Axials in Western Prome,' included them in that group. When writing that paper, the age of these hill-rocks was quite problematical, and beyond the general absence of fossils in the limestones and the mineral character of the beds, so different from that of the recognised Nummulitics, there was little or no evidence to which group they should be assigned; and the balance seemed to tend towards their union with the older or axial group. During the following season, however, (1870-71), I accumulated evidence, of an opposite tendency, not only by a more extended examination of the ground occupied by them, but I had the good fortune likewise to detect Nummulites in one of the outcrops of limestone, alluded to by me in note at page 38 (loc. cit.), which I had not previously had the opportunity of visiting, thereby demonstrating the relation of a portion at least of these hill rocks, of hitherto uncertain age, with the newer nummulitic group, in spite of their often excessively changed character, rather than with the older Axials, with which they had been previously included. I must defer, however, a discussion of this question for another occasion.

CALCUTTA,
8th August 1872.

W. THEOBALD.

I append a list of springs, a great number of which are not included in the published map of the province. I have therefore spelt the whole on a uniform system as given below, adding the mode used in the published map, where it differs from my own. I have endeavoured to convey the sound, so that the word cannot be mis-pronouuced through ignorance or ambiguity. The system is that already adopted in the naming of a very extensive collection of Pegu woods presented to the 'Phayre Museum', Rangoon.

Burmese names spelt on the following system:—

a	as	a	in	m*a*t	*ca*t
ah	"	a	"	f*a*ther	*ah*
y	"	i	"	s*i*n	s*y*ncopy
ei	"	i	"	n*i*le	n*ei*ther
o	"	o	"	p*o*t	l*o*t
oa	"	o	"	p*o*pe	s*oa*p
u	"	u	"	t*u*b	m*u*d
oo	"	u	"	l*u*nar	st*oo*p
ay	"	a	"	p*a*tient	st*ay*
e	"	e	"	s*e*t	m*e*t
i	"	e	"	imp*e*de	concert*i*na
ew	"	e	"	f*ew*	n*ew*

There is no *f* in Burmese, *hp* is its nearest representative; *g* is always hard.

Nos.	Report Spelling.	Map Spelling.	Remarks.
1	Hlahn-deng ...	Hlandeng ...	One and half mile west of the village. Several wells in the rocky bed of a stream, and a few more a little to the eastward.
2	Kadeng-mah-ngo ...	... ...	Several wells in a small stream running into the Khyoung-khoung.
3	Pyenmah-choung ..	Pyengmakhoung ...	Two springs or puddles a little way apart.
4	Toung-ngo ...	... ...	A strong spring with much marsh-gas escaping. Water very nauseous.
5	Sahn-gi	Sangyee ..	Several springs with a copious evolution of marsh-gas, but a feeble discharge of brine.
6	Hpoongi	Pwongyee.	
7			
8	Oan-nay dah-gi ...	On nay dagyee.	
9	Ki-deing.		
10	Boolay	Bhwet-lay ...	Several wells sunk in sandstone on the north bank near the mouth of the Boolay-choung.
11	Lay-myoung ...	Let myoung ...	Springs issue feebly on the top of a small hill, with a little marsh-gas.
12	Tayzahn	Tazan.	
13	Leng bahn ...	Leng bhan.	
14	Shuay-gyeng.		
15	Day-beng.		
16	Nyoung-kein.		
17	Yathaya	... ...	Several wells about one mile south by west from the village.
18	Hsengahn.		
19			
20	Oat pho	Ot pho.	
21	Num-may-ahn ...	Na ma yan ...	Several springs, rather feeble, but with a considerable evolution of marsh-gas about half a mile south-east of town on rising ground.
22	Pyouk-hsiaht.		
23	Pay-goan.		Nos. 21 to 26 all rise along the west side of the range of hills running down behind Prome in a south-easterly direction.
24	Ynah-thyt-koan.		
25	Thoan-ua boung.		
26	Wuddau-thah.		
27	Bhooyo.		
28	Hnet wah	... ...	Several wells.
29	Kahngu choung ...	... ...	The brine here rises in a sort of pocket formed by a crushed anticlinal, and we have here probably exemplified the manner in which most of the springs reach the surface, along lines rendered pervious by extreme folding, and the disruption of the lower beds.
30—35	(33) (35).		
36	Zigoan-choung.		
37			
38	Toung-myouk-choung.		
39			

Nos.	Report Spelling.	Map Spelling.	Remarks.
40—46	Hlay-gu	.. ...	These seven localities embrace many wells ranged in a line one and half miles long. They are now mostly abandoned
47	Kamyeng-choung.		
48			
49	Shuaybandau.		
50			
51—53	Kweng-hlah.		
54 & 55	Oashyt-Kweng.		
56	Thayetsahn.		
57	Paybeng-goan.		
58	Chin-uah-gi.		
59			
60	Sayay-kweng.		
61	Shah-si-bo.		
62	Kway-mah	.. ..	There are some six wells here.
63	Khyon khya ...		The brine of Nos. 63, 64, and 65 said to be very salt.
64	Hsi-soan.		
65	Tsahnda-choung, *N.*		
66	Ditto, *S.*		
67			
68	Piah-hoan.		
69	Boodalet.		
70	Mioung.		
71	Sahdwyngi ...	..	This is the most copious and important spring in Pegu.
72	Adwynzyn.		
73	Kayahndwyn.		
74	Minahgwyn ..	..	There is a cluster of some thirty wells here within a mile of this.
75	Kway choung kweng.		
76	Thayet-goan.		
77	Wuddaw kweng.		
78			
79	Hlay goan.		

Nos. 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, and 79 had been already examined and fixed by Mr. W. Blanford. The great majority of the remainder have been visited by myself, whilst many of them have been independently examined by Mr. Fedden likewise. It must not, however, be supposed that the above list exhausts all the localities where brine may possibly occur, but only attempts to give as complete an enumeration as possible of the sites where salt has been formerly extracted.

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AUSTIN, JAMES G.—A practical treatise on the preparation, combination, and application of Calcareous and Hydraulic Limes and Cements, (1862), 8vo, London.

BLAKE, WM. P.—Notices of Mining Machinery, (1871), 8vo., New Haven.

DESOR, E., ET LORIOL, P. DE.—Échinologie Helvétique. Description des Oursins Fossiles de la Suisse, with Atlas, (1868-72), 4to., Paris.

DUPONT, E.—L'Homme pendant les Ages de la Pierre dans les environs de Dinant-sur-Meuse, 2nd Edition, (1872), 8vo., Bruxelles.

FERGUSSON, JAMES.—Rude Stone Monuments in all Countries; their age and uses, (1872), 8vo., London.

FRITSCH, DR. ANTON.—Cephalopoden der Böhmischen Kreideformation, (1872), 4to., Prag

FROMENTEL, E. DE.—Introduction a l'Étude des Polypiers Fossiles, (1858-61), 8vo., Paris

HARCOURT, CAPT. A. F. P.—The Himalayan Districts of Kooloo, Lahoul, and Spiti, (1871), 8vo., London.

LEAVITT, T. H.—Facts about Peat as an article of fuel, (1867), 8vo., Boston.

Matériaux pour la Carte Géologique de la Suisse, Parts 6 to 9, and 11, (1869-1872), 4to, Berne.

MEUNIER, STANISLAS —Cours Élémentaire de Géologie Appliquée, (1872), 8vo., Paris.

MORFIT, C.—A Practical Treatise on Pure Fertilizers, (1873), 8vo, London.

ORMATHWAITE, LORD.—Astronomy and Geology compared, (1872), 8vo., London.

PALMIERI, PROF. L —The Eruption of Vesuvius in 1872, (1873), 8vo., London.

Reports of the United States Commissioners to the Paris Universal Exposition, 1867, Vols. I—VI, (1870), 8vo., Washington.

DEPT. OF STATE, WASHINGTON, D. C.

The Coming Race, (1871), 8vo, London.

VOGT., CARL —Lehrbuch des Geologie und Petrefactenkunde, Band II, Lief. 1—3, (1871-72), 8vo., Braunschweig.

VOSE, G. L.—Orographic Geology, (1866), 8vo., Boston.

PERIODICALS.

American Journal of Science and Arts, 3rd Series, Vol. V, Nos. 26 to 28, (1873), 8vo., New Haven.

Annales des Mines, 7th Series, Vol. II, Liv. 6, (1872), 8vo, Paris. — L'ADMINS. DES MINES.

Titles of Books. *Donors.*

Annals and Magazine of Natural History, 4th Series, Vol. XI, Nos. 63 to 65, (1873), 8vo., London.

BLOCHMANN, H.—Bibliotheca Indica, New Series, No. 275, Ain-i-Akbárí, Fasc. XVI, (1873), 4to., Calcutta. GOVERNMENT OF INDIA.

CORA GUIDO.—Cosmos, No. II, (1873), 8vo., Torino.

THE AUTHOR.

Geological Magazine, Vol. X, Nos. 3 to 5, (1873), 8vo., London.

Indian Economist, with Agricultural Gazette, and Statistical Reporter, Vol. IV, Nos. 8 to 10, (1873), 4to., Bombay. GOVERNMENT OF INDIA.

London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science, 4th Series, Vol. XLV, Nos. 299 to 301, (1873), 8vo., London.

Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Jahrg., 1873, heft 1-2, (1873), 8vo., Stuttgart.

Paléontologie Française, 2nd Series, Vegetaux. Terrain Jurassique, liv. 1-9, 8vo., Paris.

PETERMANN, DR. A.—Geographische Mittheilungen, Band XIX, Nos. 1 to 4, (1873), 4to., Gotha.

Professional Papers on Indian Engineering, 2nd Series, Vol. II, No. 8, (1873), 8vo., Roorkee. THOMASON COLLEGE.

Quarterly Journal of Science, Nos. 37 and 38, (1873), 8vo., London.

GOVERNMENT SELECTIONS, &c.

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THE SURVEY.

BOMBAY.—General Report on the Administration of the Bombay Presidency for the year 1871-72, (1872), 8vo., Bombay.

BOMBAY GOVERNMENT.

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DITTO.

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CHIEF COMMISSIONER, BRITISH BURMAH.

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RESIDENT, HYDRABAD.

INDIA.—Annals of Indian Administration in 1871-72, Vol. XVII, part 1, (1873), 8vo., Serampúr.

GOVERNMENT OF INDIA.

Government of India: Civil Budget Estimate for the year 1873-74, (1873), flsc. Calcutta.

DITTO.

Titles of Books. *Donors.*

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Selections from the Records of the Government of India, Foreign Department, No. 100. Report on the Political Administration of the Rajpootana States, 1871-72, (1872), 8vo, Calcutta.

DITTO.

THUILLIER, COLONEL H L.—General Report on the Topographical Surveys of India and of the Surveyor General's Department for 1871-72, (1873), flsc., Calcutta.

SURVEYOR GENERAL OF INDIA.

MADRAS—The Madras Experimental and Model Farms Reports for the year ending 31st March 1872, (1873), flsc., Madras.

GOVERNMENT OF MADRAS

MYSORE—Report on Public Instruction in Mysore for the years 1870-71 & 1871-72, (1871-72), 8vo., Bangalore.

MYSORE GOVERNMENT.

NORTH-WESTERN PROVINCES.—Selections from the Revenue Records of the North-Western Provinces, (1873), 8vo, Allahabad.

GOVERNMENT OF THE NORTH-WESTERN PROVINCES.

TRANSACTIONS OF SOCIETIES, &c.

AMSTERDAM—Jaarboek van het Mijnwezen in Nederlandsch Oost—Indië, Jaarg. I, Deel II, (1872), 8vo., Amsterdam.

ROYAL SOCIETY OF BATAVIA

BERLIN—Monatsbericht der König. Preuss. Akademie der Wissenschaften zu Berlin, November and December 1872, January 1873, (1873), 8vo, Berlin.

ROYAL ACADEMY OF SCIENCE.

CALCUTTA—Journal of the Asiatic Society of Bengal, New Series, Vol. XLII, part 1, No. 1, part 2, Nos. 1 & 2, (1873), 8vo, Calcutta.

THE SOCIETY

„ Proceedings of the Asiatic Society of Bengal, Nos. 2—5, (1873), 8vo., Calcutta

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„ Memoirs of the Geological Survey of India, Vol. X, part 1, (1873), 8vo, Calcutta.

THE SURVEY.

„ Records of the Geological Survey of India, Vol. VI, parts 1 & 2, (1873), 8vo, Calcutta.

DITTO.

CAMBRIDGE, MASS.—Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass, Vol. III, Nos. 5 & 6, (1872), 8vo., Cambridge.

MUSEUM OF COMPARATIVE ZOÖLOGY.

„ Illustrated Catalogue of the Museum of Comparative Zoölogy at Harvard College, No. VII. Revision of the Echini by Alex. Agassiz, Parts I & II, with Plates, (1872), 4to., Cambridge.

DITTO.

DUBLIN.—Journal of the Royal Dublin Society, Vol. VI, No. 2, (1872), 8vo., Dublin.

ROYAL DUBLIN SOCIETY.

FLORENCE.—Bollettino R. Comitato Geologico d' Italia, Nos. 1—4, (1873), 8vo., Florence.

THE SOCIETY.

The 2nd July 1873.

The sad tidings of the death of Dr. Stoliczka will have spread to many and distant lands before this brief record can be published. Among naturalists everywhere it will be felt that a man of distinguished merit and of very high promise has been prematurely lost to science. To the Geological Survey of India that loss is in a manner irreparable. In the large and ever increasing world of naturalists the disappearance of even a foremost man is only felt through reflection; it is among his immediate colleagues and in the scene of his labors that the loss of such an one falls as a very present calamity. To those who have known and worked with Dr. Stoliczka his early death will be a life-long regret.

Dr. Stoliczka's career commenced on the staff of the Geological Survey of Austria. Since 1862 he has been palæontologist to the Geological Survey of India, in which capacity he was chiefly engaged upon the Palæontologia Indica. By singular good fortune his work in that publication has been left in a very finished state. Only just before starting with the mission to Kashgar he had issued the last number of the series descriptive of the Cretaceous Fauna of Southern India, completing four large 4to. volumes. This work will form a lasting monument of Dr. Stoliczka's power as a naturalist.

His numerous contributions to several branches of Zoology do not call for mention here; but special notice must be taken of his work as a Geologist in the field, and which, as unfinished, might escape the attention it deserves. That the summits and plateaus of the Tibetan region are formed of stratified rocks representing palæozoic, secondary and tertiary formations, had long since been determined by several explorers. Stoliczka was the first to give an adequate sketch of the sequence and range of those deposits. His description of them, in the fifth volume of the Memoirs of the Geological Survey, the result of two trips made in the summers of 1864 and 1865, will form the safe basis of all future work in those regions. No one but an accomplished palæontologist could have achieved such results in so short a time. This work was an essential preliminary to the full geological study of that difficult ground.

The completion of his Himalayan work was what Stoliczka had most at heart. His enthusiasm for it has cost him his life. In the spring of last year he had made arrangements for a visit to Europe, where no doubt a worthy reception awaited him; but when he heard of the projected mission to Kashgar, he eagerly offered himself as naturalist to the expedition. Those who knew how he had felt the rigours of the mountain climate on the occasion of his last visit, and who appreciated the value of his life, tried to dissuade him from going, but with no effect. In crossing the passes in October he had an acute attack of spinal meningitis; but he rallied, and was able for active work for the rest of the journey, even for the trying detour over the Pamir in April. It was in crossing the Korakoram on the 16th of June that he felt the first return of the fatal disease,—this time in his neck and head. Still even on the 18th he was able during the march to make observations on foot. That evening he fell into a semi-unconscious state, and remained so till he died about noon on the 19th. His remains were interred with all honours by the officers of the mission, his fellow travellers, on the 23rd, at Leh.

In [illegible] received from him, dated the 12th, he wrote disparagingly of the geological work [illegible] been able to accomplish, the ground having been for the most part deeply co[illegible] snow. He had probably already given us all the leading features in the several [illegible] been published in our Records. Of the rare zoological collections he had [illegible] with great satisfaction.

[illegible] Stoliczka only attained the age of 36 years.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1874. [August.

GEOLOGICAL OBSERVATIONS MADE ON A VISIT TO THE CHADERKUL, THIAN SHAN RANGE, *by* DR. F. STOLICZKA, *Naturalist attached to the Yarkand Embassy.*

After a stay of nearly a month in our embassy quarters at Yangishar, near Kashgar, the diplomacy of our envoy secured us the Amir's permission for a trip to the Chaderkul, a lake situated close on the Russian frontier, about 112 miles north by west of Kashgar, among the southern branches of the Thian Shan range. Under the leadership of Colonel Gordon, we—Captain Trotter and myself—left Yangishar about noon on the last day of 1873, receiving the greeting of the new year in one of the villages of the Artush valley, some 25 miles north-west from our last quarters. On the 1st of January 1874 we marched up the Toyan river for about 20 miles to a small encampment of the Kirghiz, called Chung-terek; and following the Toyan, and passing the forts Murza-terek and Chakmák, we camped on the fifth day at Turug-at-bela, about 11 miles south of the Turug pass, beyond which, five miles further on, lies the Chaderkul. On the sixth we visited the lake, and on the day following retraced our steps, by the same route we came, towards Kashgar, which we reached on the 11th January.

Having had a shooting day at Turug-at-bela, and one day's halt with the King's obliging officers at the Chakmák fort, we were actually only nine days on the march, during which we accomplished a distance of about 224 miles. It will be readily understood, that while thus marching, there was not much time to search for favorable sections in out-of-the way places; but merely to note what was at hand on the road. I can, therefore, only introduce my geological observations as passing remarks.

Leaving the extensive löss-deposits of the valley of the Kashgar Daria, the plain rises very gradually towards a low ridge, of which I shall speak as the Artush range. It is remarkably uniform in its elevation, averaging about 400 feet, somewhat increasing in height towards the west and diminishing towards the east, which direction is its general strike. This range separates the Kashgar plain from the valley of the Artush river, which cuts through the ridge about eight miles nearly due north of the city. Viewed from this, the entire ridge appears very regularly furrowed and weather-worn on its slope, indicating the softness of the material of which it is composed. One would have, however, hardly fancied, that it merely consists of bedded clay and sand, mostly yellowish white, occasionally reddish, and sometimes with interstratified layers of greater consistency, hardened by a calcareous or silicious cement. On the left bank, in the passage of the river through the ridge, the beds appear in dome-shape, gently dipping towards the Kashgar plain on one side, and with a considerably higher angle into the Artush valley on the other. On the right bank at the gap all the exposed beds dip southward, those on the reverse of the anticlinal having been washed away by the Artush river up to the longitudinal axis, and thus exposing almost vertical faces. These remarkably homogeneous, clayey and sandy beds may appropriately be called *Artush beds*, and although I could nowhere find a trace of a fossil in them, it seems to me very probable that they are of marine origin and of neogene age.

The southern slopes of the ridge are on their basal half entirely covered with gravel, which in places even extends to the top, assuming here a thickness of from 10 to 15 feet. Locally the gravel beds are separated from the main range by a shallow depression, forming a low ridge which runs along the base of the higher one, and from which it is, even in the distance, clearly discernible by its dark tint. The pebbles in the gravel are mostly of small size and well river-worn; they are derived to a very large extent from grey or greenish sandstones and shales, black or white limestone, more rarely of trap, basalt, and of gneiss. With the exception of the last-named rock, all the others had been met with *in situ* in the upper Toyan valley. The pieces of gneiss belong to a group of metamorphic rock which is usually called *Protogine*. It is mainly composed of quartz and white or reddish orthoclase, with a comparatively small proportion of a green chloritic substance. The white felspar variety generally contains as an accessory mineral schorl, in short, rather thick, crystals. I shall subsequently allude to the probable source from which the protogine pebbles might have been derived.

From Artush we marched, as already stated, northwards, up the Toyan river, and for the next 22 miles one was surprised to find nothing but the same Artush—and gravel—deposits, the former constantly dipping at a high angle to north by west, and the latter resting on them in slightly inclined or horizontal strata; while among the recent river deposits in the bed of the valley itself the order of things appeared reversed. The gravels, having first yielded to denudation, were here underlying the clays derived from the Artush beds, thus preparing an arable ground for the agriculturist, whenever a favorable opportunity offered itself. A few miles south of Chungterek the laminated Artush beds entirely disappeared under the gravel, which from its greater consistency assumed here the form of a rather tough, coarse conglomerate. In the bend of the river the latter have a thickness of fully 200 feet, and are eroded by lateral rivulets into remarkably regular Gothic pillars and turrets. It is rare to meet with a more perfect imitation of nature by human art. The general surface of the gravel deposits is comparatively low, from 400 to 500 feet above the level of the river, and much denuded and intersected by minor streams and old water-courses.

At a couple of miles north of Chungterek the Koktan range begins with rather abrupt limestone cliffs, rising to about 3,000 feet above the level of the Toyan. Nearly in the middle of it are situated the forts Murzaterek and Chakmák, some ten miles distant from each other. The southern portion of this range consists at its base of undulating layers of greenish or purplish shales, overlain by dark coloured, mostly black, limestone in thick and thin strata, the latter being generally earthy. The limestone occupies all the higher elevations, and, as is generally the case, greatly adds to the ruggedness of the mountains. About five miles north of Chungterek, I found in a thick bed of limestone an abundance of *Megalodus* *triqueter*, a large *Pinna*, a *Spiriferina* of the type of *S. Stracheyi*, blocks full of *Litho-dendron* corals, and numerous sections of various small *Gastropoda*. Thinner layers of the same limestone were full of fragments of *crinoid stems*, and of a branching *Ceriopora*, the rock itself bearing a strong resemblance to the typical St. Cassian beds. In this place the shales, underlying the limestone, were partly interstratified with it, in layers of from 5 to 10 feet; and from this fact it seems to me probable that they also are of triassic age, representing a lower series of the same formation.

Proceeding in a north-westerly direction, the *Megalodus*-limestones are last seen near Murzatérek. From this place the greenish shales continue for a few miles further on, much disturbed and contorted; and at last disappear under a variety of dark coloured shales, slates, and sandstones, with occasional interstratified layers of black, earthy limestone. The strike of the beds is from east by north to west by south, and the dip either very high to north or vertical. At Chakmák the river has cut a very narrow passage through these almost vertical strata, which rise precipitously to about 3,000 feet, and to the south of the fort appear to be overlain by a lighter coloured rock. It is very difficult to say what the age of these slaty beds may be, as they seem entirely unfossiliferous, and we can at present only regard them as representing, in all probability, one of the palæozoic formations.

About five miles north-west of Chakmák a sensible decrease in the height of the range takes place, and with it a change in the geological formation. The palæozoic beds, although still crossing the valley in almost vertical strata, become very much contorted; while, unconformably on them, rest reddish and white sandstones and conglomerates, regularly bedded, and dipping to north-west with a steady slope of about 40 degrees. The rocks, though evidently belonging to a comparatively recent (kainozoic) epoch, appear to be much altered by heat, some layers having been changed into a coarse grit, in which the cement has almost entirely disappeared. I have not, however, observed any kind of organic remains in them. A little distance further on they several times alternate with successive, conformably bedded, doleritic trap. The rock is either hard and compact, being an intimate, rather fine grained mixture of felspar and augite in small thin crystals, or it decomposes into masses of various greenish and purplish hues, like some of the basic greenstones.

After leaving the junction of the Suyok and Toyan (or Chákmák) rivers, and turning northwards into the valley of the latter, the panorama is really magnificent. Shades of white, red, purple and black compete with each other in distinctness and brilliancy, until the whole series of formations appears in the distance capped by a dark bedded rock.

Although, judging from the greater frequency of basaltic boulders, we already knew that this rock must be found further north, we hardly realised the pleasant sight which awaited us on the march of the 4th January, after having left our camp at Kulja, or Bokum-bashi. The doleritic beds increased step by step in thickness, and after a few miles we passed through what appears to be the centre of an extensive volcanic eruption. Along the banks of the river columnar and massive basalt was noticed several times, with occasional small heaps of slags and scoriæ, among a few outcrops of very much altered and disturbed strata of red or white sandstone, thus adding to the remarkable contrast of the scene. In front of us, and to the right, stretched in a semicircle a regular old Somma; the almost perpendicular walls rising to about 1,500 feet above the river, and clearly exposing the stratification of the basaltic flows, which were successively dipping to north-east, east, and south-east. On our left, as well as in an almost due western direction, portions of a similar Somma were visible above the sedimentary rocks, all dipping in the opposite way from those ahead of us. The cone itself has in reality entirely disappeared by subsidence, and the cavity was filled with the rubbish of the neighbouring rocks.

Passing further north we crossed a comparatively low country, studded with small rounded hills and intercepted by short ridges with easy slopes; the average height was between 12,000 and 13,000 feet. This undulating high plateau proved to be one of the head-quarters of the *Kulja* (*Ovis Polii*), chiefly on account of the very rich grass vegetation which exists here. For this the character of the soil fully accounts. The entire ground was shewn to consist of limestone gravel and pebbles of rather easily decomposing rocks, mixed with the ashes and detritus, evidently derived from the proximity of the volcanic eruption. Only sandy was an isolated basaltic dyke seen, or the tertiary sandstone cropping out from under the more recent deposits.

Viewing the country from an elevated position near our camp at Turug-at-bela, the conglomerate and gravel beds, well clad with grass vegetation, were seen to stretch far away eastwards, and in a north-easterly direction across the Turug pass; while on the south they were bounded by a continuation of the somewhat higher basaltic hills. Towards the west I traced them for about seven miles, across a low pass at which a tributary of the Toyan rises in two branches; while on the other side two similar streams flow west by south to join the Suyek river. To the north the proximity of a rather precipitously rising range shut the rest of the world out of view. For this ridge the name Terek-tagh of Humboldt's map may be retained; its average height ranges between about 16,000 and 17,000 feet. In its western extension it runs almost due east-west, composed at base of a tough limestone conglomerate of younger tertiary origin, followed by white dolomitic limestone, and then by a succession of slaty and dark limestone rocks, the former occasionally showing distinct signs of metamorphism, and changing into schist. All the beds are nearly vertical or very highly inclined, dipping to north by west, the older apparently resting on the younger ones. North of Turug-at-bela the range makes a sudden bend in an almost northerly direction, and continues to the Chaderkul, where it forms the southern boundary of the lake-plateau. By this time the white dolomitic, and afterwards the slaty beds, had entirely disappeared, and with them the height has also diminished. A comparatively low and narrow branch of the range which we visited consists here entirely of dark limestone, which in single fragments is not distinguishable from the Trias limestone of the Koktan mountains, but here it does not contain any fossils. The ridge itself, after a short stretch in a north-east-by-north direction, gradually disappears under the much younger conglomeratic beds.

Across the Chaderkul plain the true Thian Shan range was visible, a regular forest of peaks seemingly of moderate and tolerably uniform elevation. The rocks all exhibited dark tints, but most of them, as well as the hills to the west of the Chaderkul, near the sources of the Arpa, were clad in snow. The lake itself was frozen, and the surrounding plain covered with a white sheet of saline efflorescence.

Brief sketch of the geological history of the hill ranges traversed.—In order that the preceding remarks may be more easily understood, I add a few words regarding the changes which appear to have taken place at the close of the kainozoic epoch within the southern offshoots of the Thian Shan which we visited.

Short as our sojourn in the mountains was, it proved to be very interesting and equally instructive. Humboldt's account of the volcanicity of the Thian Shan, chiefly taken from Chinese sources, receives great support; but we must not speculate further beyond confiding in the expectation that both meso- and kaino-zoic rocks will be found amply represented in it.

As far as our present researches in the physical aspect of the country extend, we may speak of three geologically different ranges: the *Terek range*, which is the northernmost, the *Koktan* in the middle, followed by the *Artush range*, below which begins the Kashgar [illegible]ree decrease in the same order in their absolute height, the last very much [illegible] the middle one. The first consists of old sedimentary rocks, the second of [illegible] its southern parts, while younger tertiary and basaltic rocks occupy the [illegible] portions, the third is entirely composed of young tertiary deposits. The general direction of all the ranges is from west to east, or nearly so; this direction evidently dating from the time when the whole of the Thian Shan chain was elevated. The undulating high plateau between the Terek and the Koktan is, near Turug-at-bela, about eight miles wide, the distance between the two ranges diminishing westward, while in the opposite direction it must soon more than double. Judging from the arrangement of the pebbles, which, as already noticed, are half derived from limestone, the direction of the old drainage must have been from west to east, and must have formed the headwaters of the Aksai river, which on the maps is recorded as rising a short distance east of the Chaderkul. Similarly, the gravel valley between the Koktan and Artush ranges indicates a west to east drainage, and its width appears to have approximately averaged 20 miles. About three miles north of Chungterek a secondary old valley exists, also extending from west to east, and is diametrically cut across by the Toyan river. In this valley, which was formerly tributary to the one lying more southward, the gravel beds accumulated to a thickness of fully 100 feet. As the Artush range did not offer a sufficiently high barrier, masses of the gravel passed locally over it or through its gaps into the Kashgar plain, which itself at that time formed a third large broad valley.

Thus, at the close of the volcanic eruptions in the hills north of Chakmák, we find three river systems all flowing eastward, and made more or less independent of each other by mountain ranges, about which it would, however, not be fair to theorize (in the present state of our knowledge) on the causes of their assumed relative position. It must have been at that time that the pebbles of protogine were brought down from some portion of the hills lying to the west; and it would be interesting to ascertain whether or not this rock is anywhere in that direction to be met with *in situ*. When the turbulent times of Vulcan's reign became exhausted and tranquillity was restored, the whole country south of the axis of the Thian Shan must have greatly subsided, and the wider the valleys have been, the more effectively was the extent of subsidence felt. To support this idea by an observation, I may notice that north of Chungterek, at the base of the Koktan range, the Artush beds have entirely disappeared in the depth, and the gravel beds overlaying them dip partially under the Trias limestone, a state of things which cannot be explained by denudation, but only by subsidence and consequent overturning of the older beds above the younger ones. A similar state of things is to be observed on the Terek range, where the young tertiary limestone conglomerate is in some places of contact overlain by the much older dolomite. Now, if the broad valley of the Kashgar plain sank first, and gradually lowest, as it in all probability did, we find a more ready explanation of the large quantities of loose gravel pouring into it and accumulating at the base of the Artush range.

The sinking in of the volcanic centre north-west of Chakmák first appears to have drained off the former head of the Aksai river, making it the head of the Toyan instead; and to the north of the Terek ridge it was most probably the cause of the origin of the Chaderkul. The subsidence of the country followed in the south, making it possible for the united Suyok and Toyan rivers to force their passage right across the Koktan range, strengthen the Artush river, cut with facility through the Artush range, and join the Kashgar-daria. While thus indicating the course of the comparatively recent geological history of the ground, it must be, however, kept in mind, that this change in the system of drainage had no essential effect upon the direction of the hill ranges. This, dating from much older times, was mainly an east-westerly one, following the strike of the rocks which compose the whole mountain system.

KASHGAR,
16th January 1874.

NOTE.—Since the foregoing paper was in type, the calamitous news of Dr. Stoliczka's death has been received. This opportunity is therefore taken of publishing a few last geological notes communicated in a private letter. The following is from a letter dated Kila Panj, Wakhan, 14th April 1874:—

"We crossed from Yangihissar to Sirikul in ten days; and after two days' halt at that place, crossed Pamir Khurd in twelve days. The last few marches on this side were about the worst we had. The road is very bad, and the daily snow-storms so heavy, that on one day we were not able to make more than five miles. Wakhan itself is a miserably poor country; and it is a question whether we shall be able to get enough supplies to take us back, if we do not get something sent up from Fyzabad. Our ponies will require at least twelve days to recover from the fatigue they had on the little Pamir. Whether by that time the road by Pamir Kalan will be open is very questionable.

"I ought to tell you something of the geology, but it is in very few words. There are no younger rocks the whole way than trias limestone. The Pamir Khurd proper is all gneiss and metamorphic schist. Do not imagine that the 'roof of the world' is an elevated plain; nay, it is a mere valley, well supplied with gneiss and boortsee, and from two to three miles in width. From the hills to the south, glaciers come down almost into the valley; while the hills on both sides were deeply clad in snow; so much so, that for several miles not even a few square feet of bare rock was visible. If we go back by the Pamir, I shall try to make a halt of two days before reaching Sirikul, and examine the triassic limestone. The old slates give no hope of yielding any trilobites."—EDITOR.

ON THE FORMER EXTENSION OF GLACIERS WITHIN THE KANGRA DISTRICT, *by* W. THEOBALD, *Geological Survey of India.*

Preliminary remarks

The subject of the former extension of glaciers along the southern slopes of the Himalayan chain to far greater distances than they now reach to, might at first seem of necessity to involve, for the due treatment of so comprehensive a question, the examination of a far wider area than I am about to review in my present remarks, and this to a certain extent is true, for the phenomena in question undoubtedly form but a portion of a very grand and widely spread display of glacial conditions extended over an area which, from the insufficiency of our data, it were at present premature even to endeavour in the most general way to indicate by limits; nevertheless, as it is hardly possible for the more enduring results of long continued glacial conditions to be better studied or more characteristicly displayed than in the Kángra district, and as the subject, moreover, is one which has been rather neglected by previous writers, I conceive that a few remarks thereon, even confining myself to the limited area indicated, will not be altogether without interest and value as a basis whence future observations may be extended both in an eastern and western direction.

Moraines, the most striking no less than the most enduring of the products of glaciation, form so conspicuous a feature of the surface of so large a portion of the Kángra district, that the attention of the least observant traveller is rivetted by them, and I had hardly set foot in the district before I was questioned as to the origin of those trains of loose stones so common near the hills, and whose general aspect was so different from the ordinary accumulations of débris usually swept down by streams in such situations, and the magnitude of so many of the boulders in question rendering it obviously difficult to refer their transport to the agency of hill streams and suggesting rather the intervention of some mysterious or cataclysmal débâcle.

Medlicott in Memoirs, Geological Survey.

Mr. H. B. Medlicott, in his paper on Himalayan Geology dated January 1864 in Vol. III of the Memoirs of the Geological Survey of India, page 155, was the first to draw attention to the presence of 'erratic' blocks along the "base of the Dháoladhár" and to record their occurrence in this region "at so inconsiderable an elevation as 3,000 feet," but no attempt is made to define the precise limits within which these erratics occur, or to map their course. In fixing their lowest limit too at 3,000 feet, Mr. Medlicott has somewhat erred on what may be termed the safe side, since the fort of Kángra, which is the midst of them, is no more than 2,419 feet above the sea, while 2,000 feet may in round numbers be taken as the mean elevation of the isothermal line, coincident with the limits of the terminal moraines. The statement, too, that erratics first appear on the "east about Haurbágh" is likely to convey an erroneous impression as I shall hereafter show, since though undoubtedly there is a very sudden development, as it were, of these 'erratics' from Haurbágh westwards, yet their absence eastwards from this point, is due to denudational causes, and not to a sudden or local development of glacial phenomena continued along the flanks of the Dháoladhár range, west from Haurbágh merely, but of this more in the sequel.

Dr. Verchére.
Notice of erratics and floating-ice.

Dr. Verchère, in his account of the Geology of Kashmir, the Western Himalaya, and Afghan Mountains, in the Journal of the Asiatic Society of Bengal for 1867, Vol. XXXVI, Part II, page 113, describes erratic blocks north of the Salt Range, in Latitude 33°N. and refers them to the agency of floating-ice; but there does not seem anything in his description incompatible with the idea of these blocks being the disintegrated remnants of old moraines, rather than due to the transporting powers of floating-ice; and it is, I think, rather more probable than otherwise, that they will prove to be strictly connected with the erratics of Kángra, and of cotemporary origin, during the glacial period to which my present observations refer. Speculation on this point is, however, premature, and must wait the result of observations over the intermediate area, which have yet to be recorded.

Constitution of moraines.

The task of tracing out the course of the moraines which descending from the Dháoladhár range pushed boldly across the Kángra district, is rendered unusually easy from the great contrast which exists between the rock of which the great majority of erratic and moraine blocks consist and the tertiary clays and sandstones whereon they lie. Near the boundary of the tertiary groups, the erratic blocks almost wholly consist of an easily recognised granitoidal gneiss, usually highly porphyritic, forming the central mass of the Dháoladhár range, and which rock, only towards the eastern extremity of the district, assumes a distinctly schistose or fissile habit, which proclaims its relation to the gneissose or metamorphic group of rocks, rather than to an intrusive rock or granite proper. After traversing, however, for some distance the area occupied by tertiary rocks, the moraines are found to consist, in addition to the gneiss of the Dháoladhár, of an ever increasing admixture of well rounded and water-worn boulders, from 4 inches up to 9 feet or more in girth, of the harder schistose and silicious rocks, derived from the coarse boulder conglomerates constituting the uppermost beds of the Náhun, or miocene tertiary, group through which the old glaciers ploughed their way. In proportion, too, with the decrease in number of the Dháoladhár erratics, compared with the other materials of the moraine, a diminution in size may be remarked, till eventually only an occasional small boulder, to be detected only here and there if carefully looked for, remains of the Dháoladhár gneiss, to indicate by its tell-tale presence the former extension of the glacier on which it had travelled so far; and it can therefore be readily understood how, in some cases, the actual extent of a glacier may have been greater than that assigned to it, from the difficulty, in the absence of the familiar Dháoladhár rock, of discriminating between materials properly belonging to an old moraine and the precisely similar materials

Power of denudation to obliterate moraines regulated by conditions of surface.

where the moraine has either ceased or become wasted and enveloped in deposits due to atmospheric and fluvial agency as opposed to glacial, the more so as the moraines themselves have, since the period of their final arrest, been everywhere subjected to the energetic operation of the former forces. The actual limits, however, within which it is doubtful if glaciers formerly extended or not, from the disintegration and rounding off by subsequent atmospheric action of their terminal moraines, are extremely narrow; but the vast power of denudation in particular places, and under favorable conditions of surface, and the ability of the existing rivers to remove every trace of former moraines, is in many places well illustrated in the area under review.

Sujánpúr (Glacier). Moraine breached by the Biás.

From general considerations there can be little or no doubt, that the valley of the Biás afforded passage to a noble glacier, to a point at least as low down as Nadáon, which would give a course of 120 miles in length from the snow-fields at the sources of the river; but the present main channel of the river has since that period been so deeply and sharply excavated that not a trace (or such at least as a cursory examination would enable one to detect) exists of a moraine, such as we know must have resulted from and marked the course of so extensive a glacier. At Sujánpúr the moraine of the Sujánpúr glacier is seen pushed right across the present channel of the Biás, at a much higher level than that of the present stream, which has made a clean and deep cut through it; yet, though the erratic blocks scattered round the Traveller's Bungalow at Sujánpur, and all over the truncated end of the moraine on the opposite side of the river, are of a large size, not a trace of one can be seen in the river bed beneath. This fact conclusively shows the power of the existing rivers (where from their narrowed channel, as at Sujánpúr, their effective force is largely increased) to utterly remove all traces of such deposits as these old moraines even where they contain massive boulders of 12 feet in girth and upwards; or what is rather more likely than any actual transport of such blocks is, that when once fairly sucked into the waterway, they are pounded to pieces by the incessant impact against them of the hard silicious boulders driven forcibly against them during floods. No one who has listened to the ceaseless thunder and muffled rattle of a swollen Himalayan stream can doubt the full power of such an agent to effect in time the above result.

Trunk glacier of Biás.

Again, between Mandi and the bridge over the Biás, below that town, undoubted traces are met with of the old trunk moraine of the Biás valley, where the present valley is rather open; but just above and for a long way below the bridge, the river gorge is swept perfectly clean, as with a besom, of all traces of a moraine, such as may be noticed a little higher up; and this would seem to be generally the case where the valley narrows, or is unusually precipitous, either in the main channel of the Biás, or in the channels of its tributaries, the power of moraines to withstand the erosive action of rain and rivers depending far more on the physical character of the gorges they occupy, and the slopes whereon they repose, than on either their bulk and dimensions or the magnitude and character of the materials of which they are composed.

Valley of the Ul.

Absence on it of moraines, due to its physical configuration.

The Ul (Ool) river which enters the Biás above Mandi takes its rise in the continuation of that line of snowy peaks whence the glaciers of the Kángra district descended, and no one who has examined the district, or has a tolerable map to consult, can entertain the shadow of a doubt that an enormous glacier must have once traversed the valley of the Ul, debouching into the Biás valley and uniting with the great trunk glacier of that river above Mandi. But no trace of any moraine could be detected in that portion of the Ul valley near Jatingri examined by me, and a perfectly adequate explanation of this circumstance is, I think afforded by the very steep character of the hill sides bounding the valley. The Ul valley is not only very straight, but remarkably steep, the sides in many places forming an angle of not less than 60,° so that any one who will reflect what sort of a slope in nature an angle of 60° represents, will easily understand how impossible it would be for such incoherent materials, as moraines are made of, to effect a lodgment in such a situation, and resist for ages the combined effects of floods in summer and avalanches or snow slips in spring, to sweep them *en masse* into the yawning gulph below.

Map of the district and enumeration of glaciers.

A reference to the accompanying map will give a clearer idea of the general course, arrangement and relations to each other of the glaciers which formerly traversed the Kángra district, than any mere verbal description; but neither the scale of the map nor the time I was enabled to devote to the subject suffice for any attempt at details as regards the various subordinate features and minor surface changes referable to the glacial period in question, though the sketch embraces all the essential points of the case.

Between Mandi on the east and Nurpúr on the west (being the area to which my remarks are mainly confined) seven principal glaciers descended into the valley of the Biás, which was then of course filled by a superb trunk glacier to which the above served as lateral feeders, and which taken in order from east to west may be thus described.

1.—The Dailu Glacier.

The Dailu glacier.

The most easterly feeders of this glacier passed down through the village and thannah of Haurbágh in Mandi, and after being joined by several equally large or larger glaciers from either side of the village of Dailu, the united glacier descended the narrow valley of the Rána river, which joins the Biás ten and half miles below Mandi. The most westerly feeder of this glacier was formed by the bifurcation of a huge glacier, which descending nearly opposite the village of Aiju, there split into two streams, one of which descended the Rána valley, whilst the other assumed an opposite course, and formed the most easterly feeder of the next glacier.

2.—The Baijnáth Glacier.

The Baijnáth glacier.

This glacier was formed by the union of several large glaciers, which united below Baijnáth and pursued a course down the valley of the Bimm river, which joins the Biás nearly midway between the mouth of the Rána above and the large town of Sujánpúr below. The most easterly branch of this glacier has been noticed above, as coming from near the village of Aiju, whilst the most westerly branch was similarly formed by the bifurcation of a vast glacier, which passing down a little to the east of the village of Banuri (Bunooree) was split into two streams against the cuneiform mass of hills some three miles south of that village.

3.—The Banuri (Bunooree) Glacier.

The Banuri glacier.

This glacier is the smallest, as far as the area covered by it, of any under notice, and might be regarded almost as a satellite of the next, with which it was probably intimately connected, but as some of its moraines reach the Biás by a separate course it is enumerated with the rest. It consisted mainly of the westerly feeders of the glacier above described as bifurcating south of Banuri, with some obscurely defined contributories, still more to the west, and joined the Biás some few miles above Sujánpúr.

4.—The Sujánpúr Glacier.

The Sujánpúr glacier.

This very large glacier was composed of several parallel and inosculating streams, all running with a comparatively straight course past Burwárneh to the Biás at Sujánpúr, the main stream having evidently descended along the course of the Negál river.

5.—The Haripúr Glacier.

The Haripúr glacier.

This was the largest and most interesting glacier under notice. The most easterly feeders of it passed close under Dhár bungalow past Puthiár, and thence with a grand curve south of Nagroteh; whilst the most westerly feeders descended close to Bághsu cantonments. Between these limits a number of glaciers descended from the lofty Dháoladhár range, pierced the outer range of schistose rocks, and coalescing below Kángra into one mighty stream ploughed their resistless way through the tortuous gorge of the Ban Ganga, past Haripúr, and through the village of Godeir (below which large erratics are scarce) as far as the village of Ghuriál (Ghooryal) or perhaps even farther.

6.—The Guj Glacier.

The Guj glacier.

This glacier might be appropriately named after the village of Nagroteh, near which it debouches into the plains, but as there is a better known village of that name, mentioned above, east of Kángra, it will obviate confusion if the name of the river down which it passed is substituted The most easterly feeders of this glacier descended a little west of Bághsu, the most westerly ones, a little west of Rihlu (Rihloo).

7.—The Jawáli (Juwalee) Glacier.

The Jawáli glacier.

This glacier, the most westerly one in the Kángra district, was composed of two main branches, one from the east, flowing under Tiloknáth, whilst the other passed down close under Kotleh, below which place the two united, flowing from nearly opposite directions, and together passed down the gorge of the Darh river, debouching into the plains at Jawáli. Below Jawáli the moraine of this glacier, mainly, perhaps, through the action of subsequent atmospheric forces, spreads out into a fan-shaped talus (and the same is more or less observable in the case of the Guj glacier also), so that its precise termination is not clearly marked, but it not improbably extended to the Biás either independently or after uniting with the last.

Existing glaciers of this region.

In speaking of the glaciers enumerated above I have used the past tense, as I am uncertain if at the present day even so much as a permanent remnant remains of some of them; though to the eastward of the region they originate in, towards the head of the Ul valley, snow-fields and glaciers are represented on the map. Whether or not shrunken remnants of any of them still remain pent within the deeper vallies among the peaks of the Dháoladhár range, is of little moment, since the precise course pursued by them is no less plainly marked by the Cyclopean trains of boulders they have left behind them, than if they were still present to our eyes in their original proportions.

Moraines in Kángra.

The moraines within the Kángra district present everywhere such similar features that a description of one of them will *mutatis mutandis* stand for all the rest, the differences between them being confined to their relative size, and the secondary characters impressed on them by atmospheric action, and the extent to which they have been cut into and abraded by existing streams. Descending from the central peaks of the Dháoladhár range, in the form of sinuous streams of boulders, rugged, angular, and massive, many of which attain over 50 feet in their greatest diameter, they traverse by narrow gorges the range of hills composed of schistose rocks, intervening between the Dháoladhár range and the plains of the Kángra district, on reaching which they expand, inosculating and coalescing in the open ground to such an extent as to cover the greater portion not occupied and defended against invasion by hills. In fact so complete was the union of these glaciers that the whole of the area shown in the map to have been traversed by them must have presented the appearance of one huge ice-field, if we can rely on the evidence of the perfect mantle of moraine material which now covers the ground.

Former appearance of Kángra district.

The size of some of the gneiss blocks which have travelled well out into the plains is surprising, till the mind fully realises the quasi-omnipotent power of the agency involved in their transport. Near Busnur south of Rihlu, I measured one block embedded in a field by the roadside, 125 feet in girth, and in this and other cases the present dimensions are probably much under the original size of the block, from the desquamation of the surface under the action of frost, sun, and rain, and in some situations by the friction of stones swept against them by streams. Again, between Bághsu and Dárh, four blocks in the immediate neighbourhood of the road measured in girth, respectively, 100, 125, 134, and 140 feet. Blocks of this size occur, of course, but seldom, but those from 70 to 100 feet somewhat more commonly, whilst blocks approaching 50 feet in girth are too numerous to reckon. So great is the abundance of the rocky fragments brought down by these glaciers, that the entire country just outside the narrow schistose range, which skirts the district to the north, is so covered with them as to leave no other rock visible; and but for the fact that none of these blocks can be seen *in situ*, and for the section occasionally revealed in a deeply cut river bed, the casual traveller might very naturally consider the whole area he was traversing to be granite or gneiss.

Size of erratics.

The process by which this condition has been brought about is a very simple one, but at the same time bears striking proof of the magnitude of the forces at work, and the duration of the period during which they were displayed. On quitting the narrow gorges in the hills wherein they had hitherto remained forcibly pent up between rocky walls, the glaciers at once expanded, partly through the natural tendency of a piled up mass, possessing the known plastic character of glacier ice, to spread out on a level surface, under the simple operation of gravity, and partly to the lateral displacement which later glacial accessions descending such gorges would receive from the accumulated moraines of earlier years, heaped up in their direct path, either during periodical meltings or during the secular retrocession, probably not a continuously uniform process, of the isothermal line of the terminal moraines of the whole group of glaciers in question. Exception will doubtless be taken by some to the idea of expansion through plasticity having had any appreciable influence in producing any lateral diversion of the moraine when they enter the plains, and I am prepared to admit the subordinate operation of this cause to the second one I have mentioned, but that it was a *vera causa* to a certain extent will, I think, be admitted, if due weight is given to the probable dimensions vertically of the glaciers in question. If, as has been conclusively established, a *shallow* glacier can quadruple its thickness when compressed between narrow limits, it cannot be theoretically denied the power of reassuming a shallower, that is, a more *expanded* form, when, on issuing from the hills, it becomes relieved from all pressure having a tendency to counteract the ordinary effects of gravity on a plastic body, heavily weighted by the pressure of the enormous moraines supported by it, which can hardly be so insignificant as with time to produce no appreciable result. Thirty or 40 feet is no uncommon thickness for one of these Kángra moraines, and I greatly doubt if in some cases a hundred feet

Fan-shaped expansion of glaciers on quitting the hills.

would not be an under estimate. If then we make allowance for the intermingled ice and snow, which must have cemented this prodigious mass together, we shall not greatly err if we calculate the pressure it must have exerted on the glacier, whereon it rested as equal to a stratum of solid granite of one-half that thickness, a force amply sufficient, when applied to such a thick stratum of plastic* glacier ice, as we must suppose to have been associated with such giant moraines, to have produced a very sensible lateral expansion of the ice river, initiative, if no more, of that expansion or lateral deviation, a tendency to which all the moraines, more or less, at present display on debouching from the hills.

Deviation of glaciers.

That later glaciers have thrust past earlier ones, and intersected their moraines, seems scarcely to admit of a doubt, thereby producing an irregularity and confusion in the arrangment of the erratics and materials of moraines spread over the country, at first suggestive of the less regular or sporadic agency of floating-ice rather than of glaciers, whose frequent inosculation has been the real cause of the irregularity in the network of resulting moraines.

Kángra to Bághsu.

Along the course of the road from Kángra to Bághsu numerous illustrations of the conditions sketched above present themselves. Long lines of moraines are seen to stop abruptly and sink out of sight beneath the soil; sometimes indicative of the arrest, either temporary or final, of the parent glacier, at others of the disruption and truncation of a moraine by a glacier of later date pursuing a nearly coincident course. Near Bogli, after passing the temple and tank of Gangabarabi, the road skirts a low ridge, with a well-marked moraine on the right—a long string of erratics, whose course is sharply defined; but on turning the end of the ridge, and looking towards the village of Ich-hi, the country is seen freely overspread with blocks in which no regular order can be made out.

Floating-ice—no conclusive evidence of.

The suggestion of Mr. Medlicott, as to the possible intervention of the agency of floating-ice, in distributing erratics in Kángra, here occurred to me, but I was eventually led to reject the idea, from the fact that, as far as my observation goes, these erratics never ascend beyond a certain relative height, which being no greater than that within which the traces of glaciers are found, goes far to disprove the intervention of any other agency for the distribution of the blocks in question. It is of course obvious that floating-ice and glaciers could not have cotemporaneously occurred over the same area, and the fact that no erratic blocks are known in Kángra, beyond the general limits attained by glaciers as fixed by their continuous moraines, is hence almost conclusive disproof of the agency of floating-ice within the district. The erratic blocks are so marked in character that they could scarcely escape detection, if they occurred beyond the limits above assigned to them, and this, for a negative argument, must be allowed unusual weight. If then the above conclusion is correct, the more perfect and lineal moraines are the youngest, and (trivial atmospheric denudation apart) exhibit the precise appearance they did on the waning of the glacial conditions in which they originated, whilst the more scattered and dissociated blocks must be regarded as the fragmentary remnants of more ancient moraines, whose continuity has been long since destroyed by surface changes wrought by the altered course and direction of glaciers of a later period.

Disproof of its former existence in Kángra.

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* Prof. Tyndall very justly combats the idea of ice being regarded as a 'viscous' body, properly so-called, would seem to touch the root of the matter, by limiting this so-called viscous quality of ice to a capacity of yielding to pressure, not tension. With this cardinal fact established, it is unfortunate that the term 'plastic' was not always used in place of 'viscous,' as the essential idea of adhesiveness involved in the word 'viscid' or 'viscous,' in addition to the mere property of 'plasticity,' was not really necessary to the theories of those who used the term.

All the Kángra moraines have a very arched or 'hog-backed' outline, and are always separated by a more or less strongly marked valley or ravine from the hills round which they pass. In the case of the larger moraines, the resulting effect on the landscape is rather curious: hills viewed across one of these moraines have a peculiar sunken or 'hull-down' appearance, from the crest of the moraine intercepting all view of their base, as the marine horizon does of a vessel's hull at a certain distance, and trees and villages situated on the opposite slope of one of these moraines from the observer are from the extreme curvature of its surface similarly concealed from view.

Another feature of the surface, occasionally very prominently displayed, is the rapid slope of a moraine across the valley wherein it debouches. This is well seen in the moraine west of Dailu bungalow, in the rapid slope of that portion which passes from Aiju down the course of the Rána river. The river running past the village of Dailu brings down no erratics above that village, but Dailu itself stands on the verge of an easterly branch of the same glacier which joins it lower down.

Physical features in Kángra resulting from glacial conditions.

I will now describe certain physical peculiarities of surface in the Kángra district directly connected with the glacial conditions which formerly prevailed there.

The Kángra district may be ideally divided into three vertical areas or zones.

1st, preglacial area.

Firstly, a preglacial area embracing the whole country which contributed, from peak to plain, towards the genesis and development of the glaciers under consideration; speaking roughly and without any measured data to check the estimate, the above zone or area embraces all ground higher than from 250 to 300 feet above the mean level of the present streams.

2nd, glacial area, proper.

Secondly, a glacial area, proper, embracing the entire area either occupied or excavated by the glaciers, which may be approximately fixed as commencing at the bottom of the above division and terminating below at a level of about 150 feet more or less above the mean level of the present streams.

3rd, postglacial area.

Thirdly, a postglacial area embracing the whole of the ground below the basal limit of the last division, and the rësult of aërial denudation subsequent to the cessation of glacial conditions.

The first division calls for little remark save that it is the area within which we should most naturally expect to meet with erratics, deposited from floating-ice anteriorly to the formation of the moraines of the lower ground, had any such agency been in operation; but I am unacquainted with any such, and therefore, no less than from the physical difficulties such a supposition would involve, have rejected it for the simpler one of glaciers, whose former prodigious development is so stamped on the country. By floating-ice, I of course understand ice floating at or near the sea level, since the assumption of floating-ice in some elevated inland sea, of sufficient height to bring its waters within reach, or nearly so, of the ordinary glacial isothermal of its latitude, is perfectly unwarranted by evidence, certainly at least in the Kángra district; the only fine clayey deposit, the result of a tranquil mode of deposition, which could possibly be referred to such conditions, being a red clay of clearly postglacial age, which in some parts attains considerable development and which may be referred to a postglacial period of lacustrine deposition coincident with a general subsidence of the whole Himalayan region and the gradual approximation of the general climate to that which at present obtains. This red clay covered at one time enormous areas in Kángra, and may not improbably mark a period of true lake formation, when along the southern slopes of the Himalaya lakes existed more extensively than existing indications would lead us to suppose; but denudation has to a large extent removed all traces of this finer deposit, though still to be found here and there if sought for, as, for example, south of Nadáon and between Jawáli and Nurpúr.

The second division is emphatically the area of glacial display, and to it are restricted all the moraines and erratics, which are approximately in the position where they became fixed on the waning of glacial conditions, and nowhere can the relations of this to the other divisions be better seen than near the town of Kángra.

Kángra.

Approaching Kángra by the Jullunder road after passing the village of Dowlutpúr, the road commences the ascent of a steep ridge of hills at first composed of pebbly sandstones with a little red shale, which soon give place to thick beds of very coarse conglomerate, which throughout Kángra constitute the highest sub-division of the Nahun group of tertiaries, of presumedly miocene age. The crest of the ridge is pierced by a tunnel, shortly after passing through which, and commencing the descent towards Kángra, a fine view is obtained of the celebrated fort of that name, perched on a cliff, overhanging the boiling river below, the cliff as well as some scarped heights beyond and above the fort consisting of the same coarse boulder conglomerates as those constituting the ridge over which the road is carried. When about half way down the road or rather more, a few large boulders of 'Dháoladhár' gneiss may be detected lying about, or wedged into clefts and gullies worn by surface water in the coarse conglomerate, and into which situation they have rolled from above, as these gneiss boulders in question are not weathered out of the conglomerate, but are the familiar erratics from the Dháoladhár moraines.

Contrast between gneiss boulders in stream and banks of conglomerate.

Continuing to descend, these boulders increase in number, till the stream (a branch of the Ban Ganga) is reached, when its bed is seen to be filled, and I may almost say, blocked, with enormous masses of the Dháoladhár gneiss, contrasting curiously in the eyes of a geologist with the beds of boulder conglomerates wherein the river gorge is excavated and wherein they are wholly wanting.

Immense boulder from the Nahun conglomerates.

I should not omit to notice in this portion of the road opposite Kángra, the occurrence on the road side of a large boulder of red quartzitic sandstone, of nearly 15 feet in girth. This boulder is undoubtedly an erratic, but derived from the coarsest upper beds of the conglomerates so largely here developed, but which have nearly everywhere suffered so from denudation, that little, save huge boulders strewed about, indicates their former presence. This particular boulder is interesting from being the largest from these beds I have anywhere measured, and for a true water-worn * and rolled boulder it may be considered immense, the second to it in size being, however, close on 12 feet.

Level of the base of the glaciers about Kángra.

Where the road crosses the stream the valley is narrow, but higher up it opens out more, and is seen terraced on different heights, most of such ground being under cultivation. Just below the fort stands the soldiers' church, and it would seem to mark nearly the lowest limit or level of glacial erosion proper, that is, the level of the bed of the old glaciers, or, perhaps, a trifle below it. The post office, on a slightly higher level, seems well within the vertical zone or valley of glacier erosion, and the mean between these two points may be taken as the approximate mean level hereabout of the base of the old glaciers. Passing on to the dâk bungalow scattered erratics are seen on the steep sides of the valley, becoming scarcer as we ascend

* This term of course applies to its original formation as a water-worn boulder in a coarse boulder conglomerate, not to its last vehicle of transport which I take to be 'glacial.'

to the immediate vicinity of the bungalow. Still, however, the dâk bungalow, or rather perhaps the still higher Mission church, may be regarded as marking the highest level of glacier action; and to the action at a very early epoch of a glacier descending the course of what is now a deep valley beneath the dâk bungalow to the north, I am inclined to refer the flat truncated outline of a hill which confronts the dâk bungalow at a nearly similar elevation in that direction.

The difficulty of always satisfactorily determining the upper limits to which glaciers have reached arises from the paucity of moraine débris, and erratics in such situations, especially where the ground has been steeply carved out as near Kángra; whilst the precise lower limits of glacier erosion are not uncommonly obscured by the subsidence in mass of the moraine, *pari passu* with the subsequent fluviatile and non-glacier erosion which has latterly supervened.

The third division, of postglacier erosion, calls for brief remark. Its area is freely covered by moraine débris and erratics, which, in the case of the large fragments, have simply subsided *pari passu* with that denudation which has removed the base whereon they rested. A very neat illustration of this process is seen in the bed of the stream beneath the road near the dâk bungalow. The river takes a sharp bend round a sort of promontory sharply cut out of the old plateau in which the present river has excavated its bed, and above which the old glaciers passed at a higher level. The true character of the linear trains of boulders here seen, and the fact that they are moraines subsided *in situ*, are clearly shown. These lines of boulders evidently stretched down, quite irrespective of the present river, over ground, now represented merely by the narrow spit left by the river. On this spit the boulders are seen to rest, and if it might be possible for the stream to have imparted the linear arrangement to these trains of huge boulders, it is obviously beyond the power of water to have washed them up against the face of the spit in the manner in which they occur.

Dr. Falconer on the absence of lakes south of the Himalayas.

A few words may not here be out of place touching the views held by Dr. Falconer on the causes which have acted towards the conservation of lakes in the Alps, and the probable reason of the non-existence of any lakes of similar magnitude along the vastly more colossal Himalayan range, where their presence might not unnaturally be looked for, on a scale of even greater magnitude than in the neighbourhood of the Alps; since the glacial phenomena previously described by me go far to invalidate the conclusions which Dr. Falconer, in ignorance of the former existence of the phenomena in question, was led to draw. Dr. Falconer, writing on this subject, regards the Alpine lakes (Falc. Palæont. Memoirs, Vol. II, page 651) as great fissures with rivers running into them, which originated in the process of elevation of the whole chain. Precisely similar results in his opinion followed the elevation of the Himalayas, but in the Alps a glacial period supervened, which filling these 'fissures' or lake basins with ice, prevented their being choked up with detritus, as would have happened under milder climatal conditions. For India, on the other hand, "these lake basins were gradually silted up by enormous boulders and alluvium of every kind," since in these "tropical regions the ice never descended from the highest summits down into the plains."

Views of Dr. Falconer untenable.

Now, the condition of the Kángra district clearly renders the above view of Dr. Falconer untenable, since it is abundantly clear that glaciers descended well into that outer region, wherein we might expect lakes to occur, and it is clear that no material difference existed between the Himalayas and the Alps, *quoad* climate and the former prevalence of glacial conditions over both areas. Whether at any period lakes existed within the Himalayan area, comparable with those bordering the Alps, may be allowed to remain an open question, which, I am not disinclined to think, will hereafter be answered affirmatively; but whether they once existed or no, we have in the excessive erosion of the river channels traversing the drainage basins, wherein any such lakes must have stood, a cause fully adequate to account for their subsequent disappearance. In the open ground of the Kángra district I have estimated the amount of erosion of the river beds since the termination of the glacial period as upwards of 100 feet, and there seems to me no fixed limit which we are called on to assign in the case of those larger rivers which descend from the main Himalayan chain, so that even had large lakes occupied positions along the main river vallies subsequent to the glacial period in question, we can still understand, from what is seen in the Kángra district, how such lakes may have emptied by the ordinary operation of those forces which are now and ever have been perpetually at work deepening every Himalayan gorge. I content myself, however, with throwing out the hint, as the subject is too large a one to be discussed in a paper like the present.

Period of glacial conditions in Kángra.

It remains only to add a few words on the period during which glacial conditions prevailed in Kángra, and this is capable of being fixed with tolerable exactness with regard to the tertiary deposits of the region.

'Nahun group.'

The great bulk of the tertiary deposits of the Kángra district belongs to the 'Nahun' division of Mr. Medlicott, approximating in age to the miocene of European geology. This group contains in addition to numerous Pachyderms and Ruminants (a correct and discriminative list of which is a most urgent desideratum), the remarkable Chelonian *Colossochelys Atlas*, Fal.. This group of an enormous, but unascertained thickness, not less certainly than 10,000 feet, was tilted up and involved in the great disturbance its beds display, and moulded to the main orographical features of the district prior to the development of the glacial conditions in question.

Sivalik group.

The Nahun group is followed by a series of deposits of very inferior thickness, but not less rich in remains of a varied fauna. Within the Kángra district no direct evidence exists, from contact, of the relative age of the glacier deposits and the Sivalik group; but the evidence afforded by the fauna of that group is wholly in favor of its being postglacial, and of the fauna being associated with conditions of climate analogous to those now existing. Without entering into greater detail, it is sufficient to mention in support of this view the occurrence of two living crocodiles in the Sivalik beds, and several species of land and fresh-water shells still living, and the same association of extinct types with the precursors of numerous species of living mammalia, as is seen in the pliocene deposits of the Narbada valley.

Glacial phenomena east of Kángra.

Moraines at Bilaspúr.

Erratics in the Gumber.

With regard to the occurrence of glacial phenomena along the Sub-Himalayan region east of the Kángra district, I think that future observations specially directed to the subject will reveal an unexpected amount of evidence, which, if not so obvious, will be found no less conclusive than that displayed in Kángra. The scope of my own observations only permits my saying that remnants of moraines occur in the Sutlej valley as low down as Bilaspúr, and erratic blocks, not now directly connected with any moraine, but probably transported to their present position by a prodigious trunk glacier which descended the Sutlej valley without much reference to its present configuration, as low down as the mouth of the Gumber river and probably lower. The blocks I refer to a moraine at Bilaspúr consist of the harsh Krol limestone forming the ridge which near that town is cleft by the valley or gorge of the Ullay river, down which a glacier passed into the trough of the Sutlej. Anything, however, like a connected moraine of this Sutlej glacier no longer remains; but to its disintegration and removal is no doubt largely due the enormous sheets of recent conglomerate, which literally choke the Sutlej valley, and which may be well seen, among other spots, at Dihur (at the ferry on the Mandi and Biláspur road), at Bilaspur, and at Bubhor, where the Sutlej debouches into the Una dún.

Section of the Sutlej above Dihur.

Approaching the Sutlej from the direction of Mandi, when a little better than a mile from the ferry, the whole of the high ground behind the village of Kángra is found sheeted over with beds of sandy gravel evidently the upper beds of a thick deposit of either fluviatile or lacustrine origin, mantling round the hills of harsh Krol limestone bounding the valley, which to a great extent it must have originally filled. On descending towards the river these sandy beds give place to coarse gravels, which still lower down pass into the coarsest boulder shingle, mainly composed of a heterogeneous mixture of Himalayan rocks, among which the Krol limestone of the neighbouring hills is a prominent ingredient. Among the rest, scattered boulders of the porphyritic gniess of the Dháoladhár are seen, from their size of unquestionable glacier origin, and these may be traced as low as Dihur, of various dimensions up to 8 or 10 feet in girth, associated with numbers of boulders of nearly the same size of the hardest schistose and trappean rocks, from the region of the inner hills, and all at one time probably transported to the vicinity by glacier agency.

Erratics at Biláspur.

At Biláspur in the bed of the river beneath the Rajah's Garden, I remarked erratic blocks of hard schistose rocks from 12 to 15 feet in girth, but to what precise distance down below the Gumber mouth these can be traced I cannot say.

Reflections.

But what a vision of the past is not here raised by these simple boulders lying neglected in the river bank or used for the ignoble purpose of cleansing the clothes of man's emmet-like race. As there can be little doubt that the glacial conditions to which these blocks testify, were induced mainly by the simple elevation of the whole Himalayan area, so there can be equally little doubt that such elevation was effected without materially affecting the grander orographical features of the country, and hence it comes that we must picture to ourselves as the agent employed in their transport a mighty trunk glacier, debouching somewhere above Bubhor, after a course of some 350 miles, a spectacle unmatched for grandeur at the present day in the loftiest regions of either hemisphere.

Without pursuing farther all the arguments which might be adduced, it will suffice here to summarise the conclusions which may be drawn from the glacial phenomena of the Kángra district—

1st.—That prior to the deposition of the Sivalik group, the whole Himalayan area stood at an elevation not less than 12,000 feet and perhaps 15,000 feet, higher than at present.

2nd.—That in consequence of this superior elevation, the whole of the Sub-Himalayan region north of the Duns (which had then no existence) exceeding 1,500 feet elevation, was subject to the incursion of glaciers, which from the magnitude of the drainage area whence they descended were of the most colossal proportions.

3rd.—That the Sivalik period was marked by a subsidence of the whole Himalayan area, a corresponding retrocession of glacial conditions, and a return, during the reign of the Sivalik fauna, to conditions not very dissimilar to those now obtaining in the region.

NOTE.—There are many features in Mr. Theobald's paper very tempting for the critic; but they must be left to the intelligence of the readers. One omission he has made is fairly open to editorial comment; the more so, as it affords a most instructive illustration of what threatens to become a very serious stumbling-block in geology, involving, as it does, the ignoring, abandonment, or even the inversion of the fundamental principle of the science. The evil indicated is, the blind adoption, or application, of the homotaxeous method in the classification and nomenclature of formations.

Glacial phenomena, and the 'glacial period,' having been lately very prominently under discussion, it will astonish many that in a paper treating specially of the former enormous extension of the Himalayan glaciers, no mention should be made of the possible connection of this fact with 'the glacial period'; the sole cause assigned for the case of the Himalaya being a supposed greater elevation of from 12,000 to 15,000 feet. The local time assigned by Mr. Theobald for the Himalayan glacial period may be correct: there is no doubt of its being posterior to the disturbance of the Náhan group, and to the excavation in it of the existing drainage system; and the reason given for its being anterior to the Sivalik group (as properly restricted by Mr. Theobald) is at least plausible. But here the fallacy steps in: the Sivalik formation is 'pliocene'; the 'glacial period' is 'post pliocene'; it is therefore needless to consider the relation of the latter with the prepliocene glacial period of the Himalaya, as well attempt to identify it with our Talchir (palæozoic) glacial period.

It is enough to state the case, to show the danger of it. Palæontologists are cutting themselves adrift in loosening their hold upon the chain of physical causation. Are they in a condition to say that even the Sivalik fauna (as restricted) *could* not be contemporaneous with the post-tertiaries of Europe, as is implied in the above argument?

It is plain that the possible, not to say probable, connexion of the glacial periods here and in Europe offers an incomparable means of fixing the contemporaneity or correspondence of the extinct faunas of such distant regions. The importance of this possibility will not be lost sight of.—EDITOR.

ON THE BUILDING AND ORNAMENTAL STONES OF INDIA, *by* V. BALL, M. A., *Geological Survey of India.*

In the year 1871, when at home on leave, my friend Professor Hull, Director of the Geological Survey of Ireland, informed me of his intention of bringing out a work on BUILDING AND ORNAMENTAL STONES, and invited my assistance in reference to the portion of it treating of India. Fortunately my promise of assistance was made conditionally upon my having leisure sufficient to hunt up all available authorities on the subject, as since 1871 up to the present time (April 1874), I have been almost constantly on the move, and during the short periods I have spent in Calcutta my time has been taken up by other more pressing occupations, so that I have found it utterly impossible to attempt to do anything like justice to the subject.

Professor Hull's book having been published in 1872, the present notes are printed in the Records as an instalment of what may hereafter be written. In a country covering so large an area as India, and where, in spite of the comparatively little use made of stones in modern British buildings, building stones have been employed for a long period of time by the natives, ample material exists for a very much more extensive account than the present. My chief difficulty has been to compress the principal facts within the limits available for the purpose.

By giving full references to the principal authorities on the subject, the reader is placed in possession of a means of acquiring fuller details than there is room for in the present account.

Throughout the Gangetic valley the public buildings which have been erected under the auspices of the British have until quite recently been built almost exclusively of bricks. In many cases the difficulty of obtaining a building stone within an easy distance of the towns situated in the alluvial valley, and in all the consideration of primary economy, have led to the employment of perishable bricks instead of lasting stone in the construction of our officers' courts, private residences, &c.

Character of Anglo-Indian buildings.

Even in parts of the country where good building stones are to be obtained, bricks are often the only material regularly used.

It is no doubt this feature of Anglo-Indian architecture which in part gave rise to the saying that if the English left India, in a century after their departure no sign of their occupation, save that afforded by a few empty beer bottles, would remain.

Unfortunately the use of bricks cannot be justified even by the appropriate or ornamental character of the results. If durability is sacrificed, we are justified in asking if not for ornamental structures at least for buildings calculated to make this trying climate somewhat more endurable. But what do we find? To quote the words of Major (now Colonel) Medley: "Who does not know the scene of desolation that comes over one at first sight of some of our Indian cantonments: the straight and dusty roads, the rows of glaring white rectangular barracks, the barn-like church differing only from a barrack in the presence of a square tower and classical! portico, the Roman Catholic Chapel ditto, only smaller and with bright green doors all round"? and again: "It must, I think, be allowed that the true principles of architectural construction for buildings in the east, which are to be used by men habituated to an entirely different climate, have not as yet been discovered; a mosque, for instance, has a pleasant temperature both in winter and summer, while a Gothic church in India is, as a rule, either very hot or very cold. I do not say that Gothic churches are unsuitable to India, but only that they are so as we now build them."*

Architectural results from the use of bricks.

Temples and houses built in the native style, though often somewhat close and ill ventilated, are generally considerably cooler than any European buildings. This is particularly true of the massive stone structures of the north-west.

Native buildings suited to the climate.

In new countries, such as Australia and America, the engineer or architect often experiences a difficulty in determining the durability of materials which he may wish to employ. Even in England this difficulty is not unknown, as is evidenced by the failure of the stone used in the construction of the houses of Parliament; but in India, in the civilized parts, wherever building material occurs, ancient temples or other native buildings are almost sure to be found. These furnish all the information which can be required as to the durability of the stone when exposed to the atmosphere.

Evidence of durability of material afforded by native buildings.

The other qualities in building stones—strength, appearance, and susceptibility for ornamental treatment—can all be determined by simple and readily applied tests; but there is no known speedy test of durability.

Other qualities admit of speedy tests.

The presence or absence of certain minerals, or some peculiarity in the structure, are causes sufficient to determine the decomposition, which may be more or less protracted, but which must eventuate in the disintegration of the stone and the consequent disfigurement, if not total destruction, of the building in which it has been employed.

Causes of disintegration.

* Prof. Papers on Indian Engineering, Vol. I, pp. 201-2.

With examples of stone work which range in age from before the Christian era up to modern times, the engineers and architects of India have an immense advantage over those of newer countries.

Care requisite in selection of material.

It should be scarcely requisite to observe that the proof of a certain formation affording good building stone is not sufficent to justify the conclusion that all the stone of that formation is equally durable. Yet the passing of individual blocks of stone is under these circumstances, there is reason to believe, often performed in an imperfect manner. Cases might be quoted where ill-chosen stones have not proved equal to the work which might justly be expected from the material had a little care been used in the selection, and thus, too often, a material has received a bad name and evil reputation where in truth its qualities have not been put to a fair trial.

Skilled stone-workers more numerous formerly.

Although locally, in the construction of bridges and other works where stone has been employed, vast numbers of coolies have been trained so as to become very fair stone-cutters, still the number of highly *skilled* artizans is probably less than it was in former times, when the inhabitants of almost every district in India into which Aryans penetrated erected their temples of stone. In many cases these temples, to the present day, exhibit admirable workmanship in the most difficult materials.

The building stone resources of India undeveloped.

To show how little has been done towards developing and rendering these resources of India available, it is only necessary to refer to the grim advertisements which daily meet our eyes in the newspapers, of tombstones of Aberdeen granite and Italian marble.

In further illustration of this, I may mention that at Rániganj, 120 miles inland from Calcutta, I have seen at the potteries enormous granite mill-stones for crushing quartz which had travelled probably 15,000 miles to their present destination, while within a radius of 20 miles several places could be indicated where stone suited to the purpose could be obtained were quarries only opened up.

Prospect of future development.

With increased facilities for carriage, by rail and canal, and with some modification of the traditions in favor of Public Works Department bricks, we may yet look forward to a time when the splendid building materials existing in India* will be brought into more general use for our public and private buildings. And we may thus yet hope to see structures of an ornamental and lasting character worthy of our position in this country.

The order in which the several classes of materials are arranged in this paper is that followed by Professor Hull—

I.—Granitic and Gneissose Rocks.
II.—Basalt and Traps.
III.—Serpentine, Potstones, and Soapstone.
IV.—Marble.
V.—Gypsum and Alabaster.
VI.—Ornamental Stones.
VII.—Limestones, Kunkur.
VIII.—Sandstones, Quartzites.
IX.—Laterite.
X.—Slates.

* Some trials of indigenous limestones from the Vindhyans and from Karnál for lithographic purposes appeared to give promising results; but the large quantity of stones which are used in the Presidency towns are still [illegible] exclusively imported from Europe.

I.—Granite and Gneiss.

Most of the so-called granite of India is a granitoid gneiss, a resultant of the excessive metamorphism of sedimentary rocks. To what extent true eruptive, igneous granite occurs in the peninsula is quite unknown. Granite, which from its physical relations one may venture to conclude is of truly igneous and eruptive character, is not however absent. But, as a rule, the physical relations accompanying exposures of perfectly unfoliated granites in the metamorphic areas of India are not of a sufficiently definite character to enable one to assert with confidence the nature of the origin of those granites. There is no crucial test which can be applied to determine this question. Even microscopical examination of the minerals is not now considered to afford in all cases an infallible guide. But even if it be, it is not of easy application, and cannot be made use of in the field.

These remarks seem a necessary preface to the following account, as travellers and antiquarians, who have described buildings, have not often attempted to characterise, more than by some very general term, such as granite or sandstone, the materials of which those buildings have been constructed.

The metamorphic rocks occupy a very considerable area in India.

East of a line drawn from Rotásgarh on the Són through Umarkántak to Goa, the greater part of the country consists of metamorphic rocks. The younger rocks which do occur in that area are for the most part limited to comparatively inconsiderable basins. Metamorphic rocks, not to mention small exposures within the limits of the great basaltic flows of Western India, also occur in Bandelkand, Kach, the Gáro and Kásia Hills, and in the Himalayas. Whether these all belong to the same age or not is a question of much difficulty and uncertainty. The probability is that they do not. Lithologically there is sufficient general resemblance to justify their being all classed together in this account.

The varieties of materials suited to building purposes are of course very numerous. There are those caused by structure and those due to composition. By the former character they are divisible into foliated and non-foliated. The simplest form of the latter is a binary compound of quartz and felspar, or pegmatite, sometimes appearing as graphic granite. Then there are the ternary compounds, consisting of the two minerals just mentioned, with the addition of mica, hornblende, or talc, which are known respectively as granite, syenite, and protogine. Various modifications of these four varieties are produced by the presence of foreign minerals, such as, oligoclase, schorl, garnet, epidote, magnetic iron, &c.

As building stones the dense crystalline unfoliated varieties are the most durable. The presence of garnets or magnetic iron is likely to be detrimental, as these minerals under the influence of the atmosphere are apt to disintegrate, and so mar the appearance, if they do not ultimately endanger the stability, of the edifices in which stone containing them is employed.

I shall now endeavour to give some enumeration of the principal localities where these rocks have been used for the supply of building stones, and point out the features of the principal examples.

In the alluvial tracts of Bengal ancient buildings of stone are of most uncommon occurrence. Towards the west, however, in the rocky districts and on their borders, evidence is not wanting that the art of working in stone was practised whenever the material was available. In the Ganges close to Colgong there are several small hills which form islands in the present bed of the river. These hills consist of piled masses of a very compact grey granite, which in olden times used apparently to be resorted to for material for the construction of temples. The old holes for the wedges are still to be seen, and one enormous slab, which was partially split off, was never removed, and still clings to its place.

In Behár many temples are to be found in the construction of which granite was employed. At Gya some of the Buddhistical rails and the floorings of temples, &c., are of granite.

At Barábar Hill occur, so far as I know, the only instances of artificial caves excavated in these hard rocks. In sandstones and trap, as we shall see hereafter, not a few instances can be quoted.

Throughout the Chutia Nágpur Division sandstones are generally more or less accessible, so that temples built of granite are of by no means common occurrence. But as we proceed southwards along the eastern coasts from Midnapore through Orissa, the use of granite seems to be more and more common.

At Neeltigur Hill, in Pergunnah Ultee, in Orissa, Hindu temples and deities are of garnetiferous gneiss, as are also some large figures in the Black Pagoda at Pori.

On Mahendragiri Hill, in the district of Ganjam, I observed an example of what I have since been informed was not uncommonly the practice with regard to the construction of these temples. On the top of the hill is an unfinished temple built of huge blocks of porphyritic gneiss, which on their exposed faces are rough and uncut. The practice appears to have been, not to have attempted any ornamental work until all the stones of the building were in position and then to have pared them, so to speak, into shape. One of the stones which I measured in this temple had the following dimensions, 9′ × 3′ 9″ × 3′, which would indicate a weight of about 8 tons.

The natives get over the difficulty of accounting for such megalithic structures by asserting them to be supernatural, or by saying that "there were giants in those days."

In his report on the Nilghiri Hills, Mr. H. Blanford pointed out several places where excellent building stones could be obtained from the crystalline rocks. But not much use has hitherto been made of them. In Mysore a variety is obtained, which is split into posts 20′ long, which are used for the support of the electric telegraph wire. As readily accessible examples of the useful and ornamental purposes to which the more general gneisses of Southern India have been put, Mr. King instances the following:—

A polished slab of quartzo-felspathic gneiss in the Durbar hall in the Rajah's palace at Tanjore, which measures 18′ × 16′ × 2′ 1½″.

A small temple in the north-west corner of the Pagoda Court at Tanjore, which is "a perfect gem of carved stone-work," the elaborate patterns on which are as sharp as when they left the sculptor's hands.

Other beautiful examples of carving are to be seen at the Rock Pagoda of Tr… at Volcandapuram, and at the Chellumbrum Pagoda. "Even at Trivalur near Ne… at the eastern extremity of the great delta of the Cauvery, nearly sixty miles from the gneiss quarries, the great pagoda and tank are surrounded by walls of massive gneiss.

"As an instance of the peculiar susceptibility of gneiss to fine carvings, the appended drooping corners of some pagoda buildings may be mentioned. … rings, the links within which are moveable, and the projecting corners, are carved out of single blocks of gneiss, such as may be seen at the Strimustrum Pagoda."

Mr. King also mentions the use of blocks of gneiss in the construction of walls, … of tanks, beach groynes at Tranquebar, culverts, bridges, &c.

The ancient Druid-like remains called Karumbar rings which are found in various parts of Trichinopoli generally consist of rough blocks of gneiss. In parts of Chutia Nágpur old settlements of the Kols made use of gneiss in the erection of *Menhers* and *Dolmens*. But, at the present day, the Kols who erect such memorials for the most part dwell in a part of the country where flags of schist and slate are readily accessible, and they therefore do not use gneiss.

In Madras Mr. Foote says that the beds of very hornblendic gneiss which occur "at Palaveram, Cuddapary Choultry, and Puttandulum are largely quarried for the manufacture of articles of domestic use as well as for building purposes."

Other varieties in different localities in Madras are mentioned; some of these have been quarried to a considerable extent.

Except for purely local purposes, the construction of bridges, &c., where, upon economical grounds, the rock nearest to hand has been made use of, the varieties of granite, gneiss, &c., on account of their hardness, have not commended themselves as building materials to English engineers. So far as I know, there are, throughout the country, no British buildings of importance, in the construction of which these materials have been used.

References.

	Orissa	...	... Mem. Geol. Surv., India,		I, p. 277.
Blanford,	Nilghiris	...	... „	„	p. 244.
King,	Trichinopoli	...	... „	„	IV, p. 367.
Foote,	Madras	...	... „	„	X, p. 181.

Balfour's Cyclopœdia, Art. Granite.

II.—Basalt.

Trap.—Any one who has paid attention to the subject is aware that the greater part of Western India, the Dekan, and the Central Provinces is occupied by a vast accumulation of eruptive rocks which are generally spoken of as Dekan trap. From north to south these rocks extend from a point 100 miles south of Gwalior to the vicinity of Goa, and from west to east from Bombay to Umerkántak, thus covering an area of about 1-6th of the peninsula, south of the Ganges. Roughly estimated, we may put down the area in which these rocks prevail at 200,000 square miles.

On the eastern side of the peninsula too, rocks, which, without going into details of the mineral constituents, may be conveniently spoken of generically as trap, occupy a by no means inconsiderable area, as in the Rajmehal Hills.

From the evidence afforded by the sedimentary beds with which these rocks occur interbedded, those in the west appear to be referable to the close of the cretaceous epoch, while those of the east (Rajmehal) belong probably to the jurassic.

The whole of the trap rocks which are used for building purposes are not, however, exclusively derived from the two above-mentioned sources. In many other of the recognised formations in India the trappean rocks occur as dykes; sometimes these are basaltic, but, in the older formations, diorites prevail.

In the Dekan and Rajmehal areas, other rocks are not altogether absent, as there are not only the sedimentary, interstratified rocks above mentioned, but also, on the outskirts, the deeper valleys occasionally disclose rocks of older formations.

The former, however, are not generally suited for building purposes,* and are therefore less used than trap, which, though sometimes difficult to cut, is, if well chosen, a most durable material, and is moreover susceptible of much delicate and artistic treatment.

As might be anticipated in the Dekan area, from the enormous thickness of these rocks which occur, the lithological varieties are numerous. These varieties are due both to differences in mineral composition and degrees of compactness.

With regard to the relative adaptability to building purposes of the various kinds of rock which are most commonly met with, Mr. Blanford remarks: "None of the beds containing zeolites, interspersed in irregular strings and veins throughout the mass, are good. They are too soft, brittle, and liable to decompose. None of the ash beds are equal in strength, toughness, or resistance to the atmosphere to the solid basalts, and no rock of a red colour should ever be taken for building purposes. It is almost always decomposed. Amongst the very best beds are the porphyritic basalts, such as those which form so large a proportion of the rocks on the Thull Ghât."

Mr. Bell says:—"The best I should consider to be the bluish-green basalt, which is very hard and heavy, having a specific gravity about 3·0, and which rings like a metal on being struck."

Probably the first use to which the trap rock was put in India was in the manufacture of stone implements or celts, of which specimens are occasionally found, in some cases far removed from the places where the rocks occur.

To a very early period must be referred that form of architecture which consisted in hollowing out and sculpturing the rock *in situ* into temples and dwelling places, of which we have magnificent examples in the caves of Adjanta, Ellora, and Elephanta. These caves contain sculptures and inscriptions indicative of their Buddhistical or early Brahminical origin. Several of these caves are assigned to a period from 200 to 150 years B. C.

At Gya, according to General Cunningham, some of the Buddhistical *rails* are made of basalt, others being of granite and sandstone.

Coming down to a more recent period, we find on the eastern side of India trap from the Rajmehal Hills made use of for lintels and door posts in Hindu temples, and not unfrequently for the images contained inside. Trap used in this partial manner may be seen in many of the old buildings in the vicinity of Rajmehal and the ruined city of Gaur: occasionally, too, in temples in the Burdwan District. The black marble of many writers is probably only this material. When covered by the native offerings of *ghee,* it is often, without doing what in the sight of the people would be regarded as desecration, impossible to make out the material of which the images are made.

In the famous Black Pagoda at Pori trap is said to have been much used. This material was probably derived from dykes in the metamorphic rocks.

In the Dekan and surrounding trap country this material has been used in the construction of forts and native buildings of various kinds.

One of the most magnificent works in trap is stated by Dr. Balfour to be an unfinished tomb of one of the Gwalior princes at Poona.

Recently it has been extensively used in the construction of bridges and stations on the lines of railroad which traverse the trap country, but I understand that from causes for which the stone is not altogether in fault, but rather the lime and workmanship, the work has not given complete satisfaction.

* An exception will be found noted on a following page.

In the city of Bombay trap has been used to some extent, but chiefly in rubble masonry. All the finer buildings in Bombay are constructed of a very different material, as will be mentioned in its proper place.

The principal use to which the trap rocks of the Rajmehal Hills are at present put is for the supply of Calcutta with road metal.

References.

Building materials, Bombay Island, Carter's Geology of Western India, Bombay, 1857, p. 161.

Building stone in Western India, Merewether, Prof. Papers of Ind. Eng., Roorkee, Vol. VI, 1869, p. 130.

Geology of Bombay Island, Wynne, Mem. Geol. Surv., Ind., V, 1864, p. 173.

Geology of Western India, Blanford, Mem. Geol. Surv., Ind., VI, 1869, p. 379.

Masonry in a trap country, H. Bell, Prof. Papers of Ind. Eng., Roorkee, Vol. I, 2nd Series, 1871, p. 162.

III.—SERPENTINE.

Serpentine in sufficient quantity to be deserving of mention in this enumeration is of rare occurrence in India. In the sub-metamorphic rocks of Western Bengal, I have occasionally met with it in small quantities. In the district of Singhbhum, south of the station of Chaibassa, it occurs in beds of a white limestone.

In the Madras presidency, in the eastern part of the Kadapa District, a beautiful serpentinous marble is said to occur, but it has not been much used hitherto.

Dykes of serpentine, possibly the result of alteration of some original igneous rock, occur most uncommonly in the tertiary sandstones of the Andaman and Nicobar Islands. Some of the purer varieties might, if obtainable in large blocks, be used for ornamental purposes. A black variety streaked with green, which occurs at the head of Port Blair, particularly attracted my attention. So far as I know, no attempt has been made to work it.

Serpentine is said to be found in parts of Upper Burma, where it is worked and exported to China.

Potstones.—Chloritic schists, passing, on the one hand, into talcose, and, on the other, into serpentinous rocks, occur not uncommonly in the sub-metamorphic and somewhat less frequently in the metamorphic series.

In buildings the varieties of this material have only been used on a small scale for ornamental purposes, for which some of them, as being tough and at the same time easily carved, are particularly suited. More extensively they are used in the manufacture of altars, idols, plates and bowls.

In the southern part of Mánbhum, on the frontiers of Singhbhum, there are numerous workings, which generally take the form of narrow mines which are deserted during the rains. From these mines a considerable quantity of stone is annually extracted; the blocks are roughly dressed to the shape required, be it for *Lingam*, plate or bowl. They are then fixed in a rude lathe and cut into form and given a smooth surface. When finished, they are carted off to Burdwan, where they are in great demand, and a portion are sent on to Calcutta for sale.

In the neighbourhood of Gya too, there are many large mines and quarries of this stone, which supply a considerable trade in idols and utensils.

One class of the varieties used stands fire well, while the other does not. The former is of course the most esteemed by the natives. The cracking of the latter is probably due to the water of combination in the more chloritic varieties, which becomes released on the application of heat.

In many of the ancient temples in Chutia Nágpur images made from this material are not uncommonly met with.

The beautifully sculptured doorways of the Black Pagoda near Pori are of this material, which was probably obtained from the Nilghiri Hills in Orissa.

In some of the more finished temples at Bobaneswar there are large well polished and highly sculptured slabs of potstone let into the walls. (Stirling).

In parts of Trichinopoli these rocks are applied to similar purposes.

Soap-stone.—The very beautiful steatitic material so much used for delicate carvings in Agra, though generically related to the rocks mentioned under the above head, seems deserving of separate notice in this enumeration.

This rock is obtained in the territories of the Raja of Jaipúr. In Agra it is chiefly used in the manufacture of small ornamental articles, but has not yet entered into use as a material for architectural decoration, although it is admirably suited to the purpose.

Reference.

Keene—On the Stone Industries of Agra.

IV.—Marble.

Marble in India is better known from its great beauty in the few places where it does occur and its successful employment in the ornamental architecture of some of the cities of North-Western India, Rajputana, Guzerat, and a few other places, than from being generally distributed throughout the country.

The Taj at Agra which was erected by the Emperor Jehangir, to the memory of his favorite wife Nur Jehan, is built of polished white marble, and is by many competent authorities considered to be one of the most beautiful and perfect structures in the world.

The material for this glorious monument, as well as for many others, was obtained in the Jaipúr territories.

But the special purpose to which the marble of Jaipúr has been put, and for which it is so admirably suited, is the manufacture of screens, the delicacy of the tracery on which can in many cases be only compared with lace. This work is known by the name *Jalee.* Besides marble, sandstone is sometimes, however, employed for this purpose, as the following description by Mr. Keene will show: "It is a fine filagree of marble or sandstone fretted into an almost endless net-work of geometrical combinations, such as can only be understood by seeing the carvings themselves or good photographs of them."

In the opinion of Mr. Fergusson, the *Jalee* work of Ahmedabad in Guzerat is still finer; but the style of the two is quite different.

According to Mr. Keene, the finest example of this form of work to be met with in Northern India is the following; he says: "But all the marble-work of this region is surpassed by the monument which Akber erected over the remains of his friend and spiritual counsellor Shekh Suleem Chistee at Fatipúr Sikri (1581 A. D.). In the north-western angle of a vast courtyard 433 feet by 366 feet is a pavilion externally of white marble, surrounded by a deep projecting dripstone, of white marble also, supported by marble shafts crowned by most fantastic brackets shaped like the letter S. The outer screens are so minutely pierced that they actually look like lace at a little distance, and illuminate the mortuary chamber within with a solemn half-light which resembles nothing else that I have seen. The whole of this elaborate work, including the strange but most pleasing design of the brackets, appears to have been produced by the resident stone-cutters of the place—uneducated men earning probably an average wage of about a penny a day. I believe that no instance of such pure patient workmanship, so dignified, yet so various, is to be found in the world." In a very beautifully illustrated Work on the Architecture of Ahmedabad by Mr. T. C. Hope, B. C. S., with architectural notes by James Fergusson, photographs illustrative of this work and of buildings in sandstone will be found; many of these buildings are comparatively modern, and some are quite recent. It would appear that the art of working in these materials has been more fully conserved in Guzerat than in any other part of India. But it has been by no means lost or even discontinued, though it is not extensively practised now in the northern cities.

I am informed by my friend Mr. Hacket that at Rialo in Jaipúr the *Jalee* is still made, and that the traceries in it are as delicate as any which are to be seen in the Taj. Other quarries near Jaipúr are also in operation. In the "Hand Book of the economic products of the Punjab," by Mr. Baden H. Powell, there is a list of marbles of which the following are the principal: (1) an inferior marble which, however, takes a good polish from Narnul, in the Pattiala territory; (2) grey marble from Bhunsi; (3) black marble from Kashmir; (4) white and veined marble from Sardi in Jhelum; (5) yellow marble from Manairi, Yusufzai.

In the Narbada valley, the marble rocks, justly famous for the excessive beauty of the deep gorge cut through them by the river, consist of a tolerably pure white saccharine limestone. This is the strongest local development of the calcareous element which occurs with the schists in the Bijour series of rocks.

The marble, except locally in some of the temples, has not been used for building purposes. It is much jointed on the surface, and has been a good deal crushed by tilting into the present vertical position of its beds and by the trap dykes which traverse it. But it seems probable that large blocks might be extracted, and it is possible that portions might be obtained of sufficiently fine quality for statuary purposes,* but I am not aware of any attempt having been made to use it in this way.

I must add, however, that according to Dr. Balfour's Cyclopœdia, a block sent to the Paris exhibition of 1855 (?) was pronounced to be equal to Italian marble for statuary purposes.

Several localities in Bengal might be mentioned, where more or less pure crystalline limestones occur, but these are not of much economic importance. Silica, tremolite, and serpentine are the chief foreign minerals which occur in these crystalline calcareous rocks.

* In his work on building stones, Mr. Hull mentions among other localities Syepore, Gya, and Durha in Bengal as localities where marble occurs in India. The name Syepore (whence the mineral called Syeporite) has its origin in a clerical error, and the names should stand as Jaipore or Jaipúr, as it is now spelt, and Jaipúrite. I am not aware of any marble being found at or near Gya, though the black basalt used in the temples there may very possibly have been so called by some visitor or antiquarian. As for Durha I am quite unable to trace any place bearing the name in Bengal proper. Possibly it may be Dura, near Bhurtpúr, in the Agra district of the North-Western Provinces. If so, the marble in use there probably comes from Jaipúr.

In the Khasia Hills it is said that much of the nummulitic limestone would produce most durable and occasionally very handsomely veined marble. It would answer well for ordinary purposes, chimney-pieces, slabs for tables, garden seats, and for flooring tiles.

In Southern India there are several well known localities where more or less ornamental and durable marbles are obtained; samples of these have been from time to time collected,

* Some parts are obviously too silicious to be so employed.

polished and exhibited both in Madras and Europe; favorable reports have been published, and there the matter has been allowed to rest.*

In the Palnad, according to Mr. King, there are some particularly well colored marbles. There are also breccia beds of various colors "in the western scarps of the Jummulmudgoos and the bottom of the slates in the Chey-air field." Dr. Balfour describes the marbles of the Kadapa District as being of various shades of green.

At Coimbatore, according to Mr. H. Blanford, there are crystalline limestones "susceptible of a high polish, and very transparent, which would afford a very beautiful material for internal decorations, the effect of which would be enhanced by the judicious selection of slabs of various tints. Pink and grey, occasionally approaching white, are the prevailing colors of the stone."

In Burma, for statuary purposes, marble is largely employed. The material for the well known sitting and recumbent figures of Gaudama is said to be obtained chiefly from the Tsygen Hills near the village of Mowe in the district of Madeya.

References.

Medlicott, J.—Nerbudda	... Mem. Geol. Surv., India,		II, p. 135.
Oldham, T.—Khasia Hills	... "	"	I, p. 185.
Blanford.—Coimbatore	... "	"	I, p. 247.
King, W.—Trichinopoli and Kadapa	"	"	IV, p. 370, & VIII, 292.
Keene.—Agra—Stone Industries of Agra.			
Powell, B. H.—Punjab—Punjab Products.			
Balfour.—Madras, &c., Art, Marble—Cyclopædia.			

V.—Gypsum.

As a building stone gypsum has been very little used in India. To some small extent it is manufactured locally, where it occurs, into ornaments, and is occasionally employed for mixing with lime to produce a hard and shining surface on chunam work. The manufacture of plaster of Paris from calcined gypsum appears to be unpractised by and unknown to the natives.

Gypsum in quantities of importance and deserving of notice is found only, so far as I know, in the Salt Range in the Punjab, parts of the Lower Himalayas, Spiti, Kach, and Madras.

Its manner of occurrence at these various localities varies much.

In the Salt Range, according to Dr. Fleming,† gypsum occurs scattered in irregular beds and huge mass throughout the marl in which rock-salt also occurs. It is "for the most part of a light grey color, with a shade of blue and translucent on the edges. It has a saccharine appearance, but masses in which a coarse crystalline structure prevails are by no means uncommon. Red varieties also occur, and beds of a dark grey earthy gypsum are generally associated with the saccharine kind."

It is said to be very abundant at Pind Dadun Khan. It also occurs at Mari, Kalabagh, and Surdi, where it contains quartz-crystals of various colours, which are known as Mari diamonds, and are much used by the natives for necklaces, &c. The marl on Mount Kuringil is also said to contain abundance of gypsum.

Dr. Fleming suggested the gypsum of Pind Dadun Khan being made use of by the Public Works Department for building purposes.

The marl in which this gypsum occurs is considered to be of silurian age.

* According to Mr. Balfour's Cyclopædia: "Specimens sent to the great exhibition in 1851 were favorably reported upon as indicative of a valuable material, adapted to sculptural and ornamental purposes.

† Jour. As. Soc., Bengal, XXII, p. 250.

In Mr. Medlicott's account of the Sub-Himalayan rocks of North-Western India* he states that gypsum occurs in several parts of the district; it is found in lumps in the ferruginous clays of the Subathu group, and at Sahansadhara, below Masuri, it occurs in small irregular veins through limestone.

Mr. Mallet has described the deposits of gypsum in the Spiti valley. He believes them to be derived from thermal springs, as the masses occur at all levels unstratified and amorphous, and what is more to the point, the thermal springs are at present depositing gypsum with the carbonate of lime. The origin is traced to chemical reaction between† iron pyrites and carbonate of lime, the former abounding in the underlying black slates.

Mr. Mallet concludes his observations thus: "The compact unaltered portions of the gypsum are of a snowy whiteness, and would form a beautiful material for ornamental purposes. All of it, from its apparent purity and freedom from iron, &c., might be manufactured into very superior plaster of Paris. One fatal bar, however, exists to its economic employment, namely, the mountain carriage across the entire breadth of the Himalayas."

In Kach Mr. Wynne‡ reports the existence of gypseous shales below the regular nummulitic beds; but the deposit of gypsum appears to be inconsiderable there.

In Madras gypsum occurs in several places. "It is most abundant in the Ootatoor beds (cretaceous), especially in the belemnite clays to the east of Ootatoor and in the unfossiliferous clay to the north-east of Muravuttoor.§

It might be obtained in any quantity for ordinary purposes, such as moulds; but for casts it is generally too impure; however, selected portions, chiefly in the form of transparent plates of selenite, would answer for a small demand for the latter purpose.

Dr. Balfour, in his Cyclopœdia, besides the above, also enumerates the following localities. The Chingleput District, Sadras, Ennore, the Red Hills, Nellore, Masulipatam, and Bangalore.

Gypsum is used by the natives medicinally, and can be obtained in most bazars in small quantities.

VI.—Ornamental Stones.

The use of ornamental stones in buildings in India, either in the way of mosaic or on a larger scale, has not been much practised latterly.

Probably the finest extant example is afforded by the inlaid work in the Taj at Agra. The following is a list of the stones used there as ascertained by Dr. Voysey:—

Name.	*Locality.*
Lapis Lazuli	Ceylon and Thibet.
Jasper	Basaltic trap of Hindustan.
Heliotrope	Basaltic trap of Hindustan.
Chalcedon Agate	Basaltic trap of Hindustan; also from Sone and Narbada.
Chalcedony	Basaltic trap of Hindustan; also from Sone and Narbada.
Cornelian	Basaltic trap of Hindustan; also from Sone and Narbada.
Sarde	Basaltic trap of Hindustan; also from Sone and Narbada.
Plasma, or Quartz and Chlorite	Basalt of Dekan.
Yellow and striped marble	Guzerat.
Clay slate	?
Nephrite or Jade	?

* Mem. Geol. Surv., India, Vol. III, p. 177.
† " " " V, p. 157.
‡ " " " IX, p. 200.
§ " " " IV, p. 214.

The following passage will give some idea of the elaborate character of these mosaics: "A single flower in the screen around the tombs, or Sarcophagi, contains a hundred stones, each cut to the exact shape necessary, and highly polished; and in the interior alone of the building, there are several hundred flowers, each containing a like number of stones."

In various parts of the basaltic areas of India varieties of agates and jasper occur in considerable abundance, and are collected and sold to lapidaries, who cut them into useful and ornamental articles; but they are not much used for mural decoration or mosaics at the present day. In the valley of the Narbada and Sone such pebbles are found somewhat abundantly. I believe there is no case of the original matrix, the basalt, being worked for them, but the gravelly beds of some of the tertiary rocks, which consist mainly of débris from the basalt, are mined in several places. In Western India the mines at Ruttunpur, east of Broach, are the principal. The stones found there are sold to the lapidaries of Cambay and Jabalpúr.

In the Rajmehal Hills very beautiful agates, common opal, and other varieties of silica are abundant, but are not, so far as I know, sought after or collected.

At Vellum, in Trichinopoli, some tertiary grits contain pebbles of rock crystal, smoky quartz, cairngorm and amethyst, which are cut by the local lapidaries.

References.

Voysey, Asiatic Researches, Vol. XV, p. 429.
Blanford, Mem. Geol. Surv., India, Vol. VI, p. 319.
King, Mem. Geol. Surv., India, Vol. IV, p. 370.
Keene on the Stone Industries of Agra, 1873.

VII.—LIMESTONE.

Under the head of MARBLE I have separately described those varieties of limestone which, from their crystalline structure and ornamental appearance, are entitled to be so dignified. In the present section I shall confine myself to an account of the chiefly, but not exclusively non-crystalline varieties which are used or are available for use as building materials or for the manufacture of lime.

By far the most important deposits of rock limestone in the northern portion of the peninsula of India are those which occur in the Vindhyan series. In the lower Vindhyans occurs a group of thin-bedded limestones which in the places where they are best exposed have a total of several hundred feet in thickness. At Rotásgarh it is chiefly quarried for burning. It is brought down the Sone in boats and into the Ganges, by which means it is distributed over a considerable area of country. When the Sone canal is opened this trade will probably become more regular, and it is possible that Calcutta may be supplied from this source, a contingency much to be desired in view of the great expense of Sylhet lime, which is that which is principally used at present.

Attention has been drawn to this limestone too as being, within a reasonable distance, the only source of a material of steady, known composition capable of affording a suitable flux for employment in the proposed iron-works in the Ráníganj country.

It should be mentioned, however, that the steady composition can only be depended on in individual layers, as the proportion of associated argillaceous matter varies in successive layers.

This rock has been traced as far west as the neighbourhood of Katni on the Jabalpúr line; at Múrwára, &c., quarries have been opened where the Jabalpúr railway crosses the outcrop.

Higher in the Vindhyan series the Bandér group includes a limestone which is not only used as a source of lime, but as a building stone in the Dumoh district, where it is preferred to the lower sandstone; the same is said to be the case in the vicinity of Nimach.

Some of this stone was reported on favorably for lithographic purposes, but it has never come into use.

In several parts of Bengal occupied by the metamorphic rocks limestones occur, but they are in general too much impregnated with foreign minerals to be of use either as building stones or as sources of lime.

In the neighbourhood of the Khási Hills the so-called Sylhet limestone is extensively manufactured into lime for the Calcutta market. The principal factories are at Chátak and Sonamganj, and along the banks of the river Súrma between these two villages. The quarries are "near the village of Tungwai or Tingye, from which the stone is brought to the neighbourhood of Pondua and to Chátak. Other very large quarries are in the vicinity of the great orange groves between Teria-ghât and Lacát, from which also the stone is conveyed to Chátak for burning." This limestone is of nummulitic age.

Under the head of marble will be found a notice of the portions of it which come under that denomination. How far it has been used as a building stone, locally, I have no information, but there is no reason to doubt that good building stone could be obtained.

In Western India limestones occur in the metamorphic and the Bijour series; they are, however, usually too silicious to be employed in the manufacture of lime, and I can find no notice of their being employed as building stones; but some of the highly calcareous Bágh beds and the nummulitic limestones of Guzerat are used to a certain extent. Regarding the latter, Mr. W. T. Blanford says: "It is difficult to obtain it in large masses, or to trim it neatly. It is employed by the natives for bowries, temples, &c., other compact calcareous beds being used for the same purpose."

In the north-west of India the limestones of the Lower Himalayas are, some of them, applicable to building purposes, and "some fit for ornamental or monumental purposes might be found among the thick-bedded, hard limestones of the Krol group."

The lime in this area is chiefly made from a porous tufa, which occurs along the flanks of the limestone ridges.

In Southern India limestones of at least three distinct geological periods are used as building stones. The oldest of these are the crystalline limestones of the metamorphic series. At Coimbatore there is a limestone belonging to this series which has attracted some attention, as it would make a good building stone as well as being a source of lime; while portions are highly ornamental, as is mentioned under the head of marble. This limestone is described by Mr. Blanford in the Memoirs of the Geological Survey, and at greater length in the Madras Journal of Science. Mr. King also, in his Geology of Trichinopoli, mentions this rock and gives some additional localities. He states that it has been used as a building stone in connection with the Madras and Beypúr railway, and has given complete satisfaction.

The two series of metamorphosed rocks occurring in Southern India, and which are known by the names Kadapa and Karnúl, each contain limestones. For building purposes those of the latter seem to be the most important. The Karnúl series belongs, it is considered, to the same general age as the Vindhyan of the northern parts of India. Mr. King remarks in reference to these rocks. "The limestones, where they are at hand, have been largely used by the people of the country, the larger villages in the Khoond-air valley having their better houses built of well-selected and dressed Nergee beds, while the wells of the Kadapa and this valley are all lined with this stone." Mr. King anticipates that the railway and canals will tend to develope the use of these building materials.

There are still to be mentioned the limestones of cretaceous age which occur in Southern India. These are of two kinds, one being purely sedimentary, the other derived from coral reefs. As building stones they are somewhat extensively used by the natives, but, according to Mr. H. Blanford, "are ill qualified for exposed exteriors, where they rapidly yield to the heavy tropical rains."

References.

Mallet	On the Vindhyan series, Mem. Geol. Surv., India, VII, p. 113.
Oldham	Khási Hills, Mem. Geol. Surv., India, I, p. 181.
Medlicott	Lower Himalaya, Mem. Geol. Surv., India, III, p. 176.
Blanford, W. T.	Western India, Mem. Geol. Surv., India, VI, p. 380.
Blanford, H.	Southern India, Nilghiri Hills, Mem. Geol. Surv., India, IV, p. 204, and I, p. 246.
King, W.	Trichinopoli and Karnúl, Mem. Geol. Surv., India, IV, p. 370, and VIII, p. 282.

Porebunder Stone or Miliolite.

The name miliolite was given by Dr. Carter to a rock which is found in the neighbourhood of Porebunder in Guzerat. Though somewhat oolitic in structure, it is not of oolitic age, and therefore the above name was given to distinguish it.

It is considered to be of newer tertiary, probably pliocene age. In Guzerat its greatest development is in the Gir Hills, where, as also in some of the valleys, it rests upon an arenaceous clay. It is a wide spread deposit, and is said to occur on parts of the coast of Arabia and in Kach.*

As it appears in Guzerat it is a somewhat coarse calcareous grit, abounding in foraminifera towards the west, but containing fewer organisms, and being more argillaceous towards the east. As a building stone it is admirably suited to many purposes, but is said to be incapable of sustaining great pressure. It is largely quarried about twelve miles from Porebunder, from whence it is shipped to Bombay and other places.

In Bombay it has been largely used for building purposes, more particularly in the construction of the recently erected Government buildings.

References.

Carter	Geology of Western India.
Theobald	„ Guzerat, M. S.
Wynne	Kach, Mem. Geol. Surv., India, IX, p. 81.
Balfour ...	... Cyclopædia.
Merewether ...	... Building stone in Western India, P. P. of I. E., VI, 1869, p. 137.

Kunkur or Gutin.

The calcareous concretions which occur in the alluvial clays, and which are known under one or other of the above names, occupy a very important position as a building material, being in very many parts of the country the only source of lime. In addition to this, some of the more massive varieties are used as building stones in parts of India as in the Central Doab.

In the bridges on the Ganges Canal between Rúrki and the Nanún Fork block kunkur has been largely employed, except for the archwork. In the case of the Kasimpúr bridge the external faces of the arches themselves have, however, been made of this material.

In the vicinity of this section of the canal the block kunkur is readily procurable.

Block kunkur was also much used in the bridges on the Fatehgarh and Koel branches of the Ganges Canal. It is thus described by Colonel Sir Proby T. Cautley: "In extremes, the stone may be described, in its most perfect state, as a gray semi-crystalline rock, tough,

* The Kach rock, which has been supposed to represent the miliolite, is, according to Mr. Wynne, devoid of organisms.

with occasional amygdaloidal or irregularly shaped hollows, dispersed through its mass, the hollows being filled with earth. In its most imperfect state (I allude simply to the block kunkur which is available for building purposes) these hollows are more numerous, and they give to the rock a honeycombed appearance to which I have before adverted. It is found in extensive tabular masses or strata (generally accompanied by sand), the upper and lower sides of which are slaty and apparently imperfectly indurated; the induration, in fact, increases towards the centre, where it is frequently of the hardest description of the newest lime rocks, and of a crystalline character."

Owing to the honeycombed surface of the stone, it was found necessary to protect it by stucco from the direct action of the water and of the atmosphere. This rock has also been used, where readily obtainable, in the construction of buildings connected with the railroad.

Block kunkur, similar to the above, is obtained in parts of the Jamna below the ordinary water level. Its more common form is in nodules, and in this form its occurrence is so general throughout alluvial soils in India wherever they exist that it were useless to attempt to indicate its geographical distribution in detail.

The better qualities of kunkur contain 70 per cent. of carbonate of lime; from this downwards the proportion constantly varies with the amount of clay or sand which is taken up.

Besides its usual employment for mortar, it is, when burnt and powdered without slaking, an excellent material for hydraulic cement. To this purpose of course only certain varieties are applicable.

VIII.—SANDSTONES.

Several of the recognised formations in India afford sandstones admirably suited for building, and some of them have from very early times been largely drawn upon for the supply of materials for this purpose.

Among these formations the great Vindhyan series stands pre-eminent. The difficulty in writing of the uses to which these rocks have been put is not in finding examples, but in selecting from the numerous ancient and modern buildings which crowd the cities of the North-Western Provinces and the Gangetic valley generally, and in which the stone-cutter's art often appears in its highest perfection.

The Lower Vindhyans,* consisting for the most part of shales and more or less flaggy limestones, and from the inaccessible position of the rocks in some of the principal places where they occur, as in the Són valley and Bandelkand, have not been worked to any great extent.

The Kaimúrs, however, have been worked extensively at Chunár, Mirzapúr, and Purtábpúr, as well as at minor intermediate points. The sandstones are in general fine-grained and of reddish-yellow or greyish-white colors. They occur in beds which are said to vary in thickness—at Purtábpúr and similarly elsewhere, from 6 inches to 8 feet. These beds often spread for long distances without any joints or fissures to break the continuity, in consequence of which very large blocks can and have been extracted for various purposes.

In the Riwa group, overlying the Kaimúrs, the sandstones are not so much used for building purposes.

"This is due partly to the beds being frequently coarse and harsh, and greatly subject to false bedding; partly to the fact that the Riwas do not occur much close to the Gangetic valley or to large cities. Some portions are, however, of superior quality, and supply all local wants."

Above the Riwas come the Lower Bandérs, which are described as being, for the most part, coarse, harsh, and gritty, and occurring only in thin beds.

* The following particulars are chiefly taken from Mr. Mallet's Memoir.

The Upper Bandérs, however, make up for the deficiencies of the underlying group by affording two varieties of excellent building stone, one dark-red, sometimes quite unspotted, sometimes streaked and dashed with yellowish-white spots.

The other is a yellowish-white, very fine grained rock, perfectly homogeneous both in texture and colour.

The latter is said to be, on the whole, the better building stone on account of its more uniform coloring and its being not so liable to disintegration from the effects of long continued exposure.

Probably the earliest use to which any of the rocks of the Vindhyan formation were put to was in the manufacture of stone implements, many of which, formed of the denser indurated varieties of sandstone, have been found in India.

So far as I have been able to ascertain there are no cave temples, or at least none of much note in the Vindhyan sandstones. But there are memorials of a very different class, many of which date from a period before which the idea of using stone in the construction of houses had not been entertained. At any rate, there are no buildings or remains of buildings which can with safety be regarded as belonging to so remote a period.

These memorials are the great monoliths or *lâts*, many of which bear the edicts of Asoka, the protector of the earliest Buddhists, and who reigned about 250 B. C. Besides these pillars he is said to have erected 84,000 Buddhist sanctuaries called stupas or topes.*

Some of these monoliths are of great size, and are generally polished throughout the portion intended to be exposed. They were surmounted by carved and ornamented capitals, upon which figures of lions or elephants were placed.

The polished portion of the shaft tapered uniformly from base to summit, and in every way these remarkable monuments testify to considerable skill in the stone-cutter's art. Still it would appear that this art was not made use of in the erection of buildings, and when the first stone temples† were excavated and adorned a century later, the stone architecture, as pointed out and described by Mr. Fergusson, was a "mere transcript of wooden forms," showing that at that time the art of using stone for these purposes was only being then first adopted, and that though the material was changed, the workmen continued to use the designs suited to wood. It was only gradually through several succeeding centuries that the forms and designs became suitable to the material.‡

It is considered by the best authorities that the palaces, temples, and buildings generally of those early times were mainly constructed of wood, as they are for the most part in Burma and Siam at the present day.

The resemblance between these monoliths and those of Egypt, some of which have been taken away into Europe, cannot fail to strike the attention. The connection is believed to be more than a mere apparent one, the discussion of which, however, belongs to the province of the Antiquary.

As these *lâts* afford the most striking evidence which can be given of the size of the stones which are obtainable from the Vindhyan sandstones and the durability of the material, I append the following enumeration of the principal of them which are known. The details are chiefly from General Cunningham's Archæological reports :—

* Balfour's Cyclopædia, Article Asoka.

† Stone monuments, Fergusson, 1872, p. 458.

‡ It is right to add that this deduction of Mr. Fergusson is contested by Babu Rajendra Lal Mitter. See Jour. As. Soc., Bengal.

List of remarkable Monoliths in India.

Name.	Position.	Material.	Length. Observed.	Length. Estimated total.	Diameter. Upper	Diameter. Lower.	Weight (estimated).	Age or period.
Bakra or Bhim Sen-ka lât ...	Beshrah, 27 miles east of Patna...	Polished sandstone ...	32′	36′-37′	38″ 7	49″·8	50 tons ...	Unknown.
Navandgarh	Lauria, 15 miles north of Bettia...	„	32′ 9½″	.	26″ 2	35″·5	18 tons (polished portion).	Asoka (About 250 to 200 B. C.)
Ara Raj ...	(Lauria, 15 miles north of Bettia)	„	36′ 6″		37″ 6	41″·8	34-40 tons ...	„
Firus Shah's Pillar * ...	Delhi	„	...	42′ 7″	25″·3	38″·8	27 tons ...	„
„ No. 2 † ...	(Delhi)	......	32′ 8″	.	29″·5	35″·82	...	„
Bhim Sen-ka gada ...	Kosam, on the Jumna	......	28′	36-40	29″·5	...	...	? „
Allahabad	... ...	......	...	42′	.	...	...	„
Kahaon	4[illegible] miles south-east of Goruckpúr	Coarse grey sandstone	24′ 3″	27′	.	...	...	84 A. D., or 219 A. D.
Bhutari	Between Benares and Ghazipúr ...	Reddish sandstone ...	15′ 5″	...	28″·85	...	...	? 100 A. D.

* Removed by Firuz Shah from its original site in district of Salora near Khizrabad, on the Jamna.

† Said to have been brought from Meerut.

Mr. Mallet mentions two large blocks which are found "about a mile south-east of Rupas near the quarry from which they were cut:" the dimensions of these suggest a near connection with those enumerated above. Not improbably they belong to the Asoka period. One is a circular column 34′ 6′ long, with upper and lower diameters of 2′ 8″ and 3′ 3″. The other is a parallelopiped 42′ 6″ long by 5′ 3″ × 3′ 8″ and 5′ 9″ × 4′ 1″, with an estimated weight of nearly 60 tons. The neighbouring villagers appear to know nothing of their history.

The quarries at Dehri on the Són are the most eastern of all those which have been opened in the Vindhyan rocks. At present they are largely worked in connection with the Són irrigation and canal projects. The stone is a compact whitish sandstone susceptible of artistic treatment, and, what is of more importance for the present purpose to which it is put, strong and durable.

The next point of importance where there are quarries is Chunár. The vicinity of the Ganges has, during a period of at least 2,000 years, afforded a ready means of transport for the excellent building stones which are obtained from the Kaimúr rocks at Chunár.

The East Indian Railway now affords an additional means of transport, but is, however, I believe, not very much used for the purpose, water carriage being so very much cheaper.

Benares, and other cities and towns of less note, both in ancient and modern times, have largely used Chunár sandstone. The ghâts at Benares, the palaces, the walls, the minarets, and many of the temples are built of this material. To Calcutta a certain quantity is brought for paving and tombstones, &c. The only stone church in Calcutta is St. John's, which is built of Chunár stone.

It has also been used to some extent in other buildings in Calcutta, but for paving purposes, as has elsewhere been shown, the so-called Burdwan stone has also been employed.

The next quarries to be mentioned are those of Mirzapúr, which, with those of Purtábpúr and Seorájpúr, have supplied Mirzapúr and Allahabad with material for the construction of their buildings, both ancient and modern. The stone for the Jamna bridge was, according to Mr. Mallet, obtained from some quarries a few miles up the river, whence it was brought down in boats.

From this the limits of the Vindhyan rocks sweep southwards in a great bay, and the next place where they have been worked to any large extent is in the neighbourhood of Gwalior, where they have been used in the construction of forts, temples, &c. It may be mentioned too that in the exposed faces of sandstone there are carved some figures of Titanic dimensions.

Although, as was remarked, the sandstones of the Riwa group are not generally used, still "in the neighbourhood of Hosungabad and also in the Sípri and Gwalior districts some thin red flags from ½ to 1 inch thick are much used for roofing."

Perhaps the most important quarries in India are those in the upper Bandérs to the south of Bartpúr, at Fatipūr Sikri, and Rupás, which have furnished building materials since before the commencement of the Christian era to the cities of the adjoining plains. Portions of the Taj at Agra, Akber's palace at Fatipūr Sikri, the Jamma musjid at Delhi, and generally the grandest and the meanest buildings in Agra, Delhi, and Mutra (Mathura) have drawn upon these quarries for their materials.

To quote Mr. Mallet again: "The palace of the Rajah of Bartpúr at Deeg, which is regarded as one of the most beautiful edifices in India, testifies at once to the excellence of the stone employed and the skill attained by the stone-cutters of that district. Cupolas resting on slender shafts of 2 and 3 inches diameter, arches supported on strong, yet graceful pillars, windows formed of single slabs of stone perforated into the most elaborate tracing, meet one at every turn."

In conclusion, it may be mentioned that the sandstones both here and at Chunár have been largely used for telegraph posts; the facility with which some of the varieties split renders it possible to obtain posts 16' long of material which will resist white ants and the action of the weather.

Thus the ancient pillars of Vindhyan sandstone have been instrumental in annihilating time by preserving in an imperishable record fragments of the history of upwards of two thousand years ago, while the posts of to-day have been subservient to the destruction of space, for it may be said that the telegraph which bears our messages from Calcutta to Peshawur over a distance of 1,500 miles in a few seconds of time practically overcomes space.

The preceding remarks refer only to the Vindhyan rocks, as exhibited in the great Vindhyan and associated ranges on the south of the Gangetic valley. In order to complete this notice, it will be necessary to allude to the occurrence of rocks believed to belong to the same geological period in other parts of the peninsula.

Between Sambalpúr and Raipúr in the valley of the Máhánadi, a series of sandstones, shales and limestones, considered to be contemporaneous with some of the Vindhyan series, occupy a considerable area. But in that wild part of the country there has as yet been no local demand for building stones.

Again, rocks referable to the Vindhyan series occur in the country to the south of Nágpúr, in the region about the confluence of the Weinganga and Warda rivers.

In the Karnúl district south of the Kistna there is another series of limestones, shales and quartzites which is considered to be referable to the Vindhyans.

Mr. King, in his description of these rocks and the underlying Kadapa formation, says: "There is no lack of good and easily wrought stone all over the district; but these can only become of value as they are locally required or as the means of communication are opened out over the district."*

For further examples of the uses to which these sandstones have been put in ancient times reference should be made to General Cunningham's Archæological Survey Reports.

Among the sandstones of the Dámúda series (the representative of the carboniferous period in India) there are several varieties which are suited for building purposes and which have already to a small extent been made use of.

Throughout the Dámúda valley where these rocks occur, they have been used in the construction of temples, some of which are of considerable antiquity. Among the finest examples three Jain temples at Barákar are deserving of particular notice, as exhibiting some rather elaborate carving which has stood well.

But still more ancient work in this material is to be seen in the caves of Sirguja and Cháng Bokhár, which bear inscriptions in the old *Pali* character, testifying to their extreme antiquity.

In recent times the sandstones at Barákar have been quarried largely for local use in the construction of the Barákar bridge and for various purposes in connection with the East Indian Railway. A considerable portion of the new High Court in Calcutta is also built of this material. Being readily accessible at the terminus of the Barákar branch of the railway, this rock will probably always be more or less used for purposes to which brick is not suited.

In Hazáribágh and Ránchi some of the sandstones of this series have been used to a small extent, and the flaggy beds of the underlying Tálchírs to a somewhat larger extent for paving the European barracks, &c.

References to these sandstones will be found in the numerous reports on coal-fields in the Memoirs and Records of the Geological Survey.

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* *References.*

Voysey, on the building stones and Mosaic of Akberabad or Agra, Asiatic Researches, XV, 1825, p. 429.
Owen, Purtabpúr stone quarries, P. P. on I. E., II, 1865, p. 81.
Blanford, W. T., Western India, Mem. Geol. Surv., India, VI, 218.
Mallet, Vindhyan series, Mem. Geol. Surv., India, VII, p. 118.
King, Kadapa and Karnúl formations, Mem. Geol. Surv., India, VIII, p. 281.

The sandstones of the various groups included in the Máhádévá series have been largely used; the members of the lower groups are, however, in many cases either too friable or contain too much iron to be lasting when exposed to the atmosphere.

In the Bágra group, a sub-division of the Máhádévás, there are sandstones applicable to building purposes, and which have been used to some extent locally. The Tawa viaduct is built of these sandstones.

Some of the beds of sandstone in the Jabalpúr group yield an useful building material. A very dense indurated variety, which occurs in the station of Jabalpúr, has been quarried to a considerable extent for local purposes.* The viaduct over the Narbada below Jabalpúr furnishes the most important example of the applicability of the sandstones of this group to building purposes.

Close to Katák (Cuttack) there are some sandstones which Mr. Blanford considers to be younger than the Máhádévás, but the exact age of which is, from the absence of fossil remains, still uncertain. These sandstones were used in the construction of temples at Bobaneswar, and to some extent for various building purposes in Katák; but laterite and gneiss seem to have been more largely employed. Some ancient caves at Kundageree have been excavated in these rocks.†

The intertrappean rocks of the Rajmehal series, whose contained fossil plants present a markedly jurassic facies, consist of sandstones, flag beds, and shales. The two former are occasionally employed for local building purposes, but cannot be considered to be of much importance.

The compact sandstones of this series at Conjeveram and several other places offer, according to Mr. Foote, a very easily dressed and moderately durable building stone.

In reference to the jurassic rocks of Kach, Mr. Wynne says: "The finer grained slightly calcareous yellow sandstones of the lower jurassic group form tolerable building stone; and some of the close, hard silicious grit bands, though difficult to trim or dress fine, would afford a very lasting material for rough work."

Several other sandstones are locally used. Mr. Wynne gives a list of the different building stones used in Bhúj, as furnished to him by His Highness the Rao of Kach.

Rocks of this age are found in the Rajmehal Hills, Utatúr (Ootatoor), and at various places on the east coast between Trichinopoli and the Godáveri and in Kach.‡

The Bágh beds, which belong, it is considered, to the cretaceous period, contain some good sandstones suited to building purposes. Mr. Blanford, in his report on Western India, says: "The massive sandstone of the Déva and those which occur throughout the country to the south of Allirájpúr and Bágh would furnish excellent material. The gritty calcareous bed at the top, where it is not too cherty, would be well adapted for construction and could be easily worked.§

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* Medlicott, Records, Geological Survey, V, p. 77.

† *References.*

Building materials of the district of Cuttack, Jour. As. Soc., Bengal, XI, p. 836.
Memoirs, Geological Survey, I, pp. 259 and 277.
Records, Geological Survey, V, p. 59.

‡ *References.*

Oldham, Jour. As. Soc., Bengal, and Pal. Ind.
Foote, on the Geology of Madras, Mem. Geol. Surv., India, Vol. X, p. 132.
Wynne, Geology of Kach, Mem. Geol. Surv., India, Vol. IX, p. 93.

§ Blanford, Western India, Mem. Geol. Surv., India, VI, p. 380.

The rocks of the Sivâlik and Náhan groups which represent the upper and middle tertiary period of Europe are generally too unconsolidated to form durable building stones. These rocks, as is well known, form the outer ranges of the Himalayas at various places from west to east.

Mr. Medlicott remarks: "Those stations, as Dagshai, Kasaoli, Subathu, Dharmsala, which are built on the eocene groups of the Sub-Himalayan series, have an unfailing supply of good building material in the massive sandstone rocks. Among the older rocks there is no stone fit for anything but that for which rough rubble may be used. There are several examples of native architecture along the border of the plains for which an excellent building stone was obtained from rocks of the Sivâlik group, but it must have been found in detached blocks and discontinuous bands, the mass of the rock being quite unfit for the purpose. Stone fit for ornamental or monumental purposes might be found among the thick-bedded, hard limestones of the Krol group."*

QUARTZITES.

The gradation from the loosest and most granular sandstone to the most intensely vitrified quartzite is so complete that it is impossible to draw a sharp line of demarcation between them. I therefore place the quartzites with the sandstones in this enumeration. Were the arrangement a purely geological one, a large portion of them would have to be classed with the schistose or gneissic rocks.

If we except those varieties of the Vindhyan and Karnúl sandstones which are sometimes called quartzites, the use of rocks coming under this denomination has been very inconsiderable. Indeed the only instance known of a quartzite being regularly quarried is in the Susinia Hill in Mánbhúm. The works there were carried on for some years by the Burdwan Paving Stone Company, and large quantities of the stone have been used in Calcutta for pavings, copings, and other similar purposes. There are several varieties of this material found; in some there is a large proportion of felspar, when it should be called granulit rather than quartzite.

Although these rocks have been so little used, the Bijaur or submetamorphic series, in many parts of the country, afford quartzites suitable for building purposes; wherever these occur in the vicinity of Vindhyan sandstones, the latter will naturally be preferred, as they are in most instances much more easily worked. The vitreous fracture of many quartzites is in fact a bar to their employment where much finish is required.

IX.—LATERITE.

The term laterite has been applied generically to a group of rocks which play an important part in the superficial geology of India. The common character which persists throughout all the varieties of laterite is the possession of a ferruginous element which is in the form of brown hydrated peroxide on the surface, sometimes as the black magnetic ore inside. The reddish-brown appearance, due to the presence of the peroxide, explains the origin of the name (*later*, a brick) which was, I believe, first conferred upon it by Dr. Buchanan.

The various forms in which laterite occurs are due to differences of composition and differences of structure. The combinations of these two qualities produce almost infinite varieties. The principal structural varieties are either nodular or cellular, the former being the younger, and it is supposed, in a measure, derived from the latter. The varieties in composition vary much in the quantity of the peroxide which they contain and in the character of the other materials. Both classes pass off into mere detrital laterite, to the ferruginous element in which they have no doubt mainly contributed.

* Medlicott, Mem. Geol. Surv., India, III, p. 175.

This is not the place for going into details or enumerating the various theories which have been suggested to account for the origin of this most singular deposit. It may be mentioned, however, that no theory accounts satisfactorily for the sources whence the large amount of iron can have been derived.

The distribution of laterite in India is widespread throughout the Peninsula, Ceylon, and in Burma. It occurs not only as a costal deposit underneath the Eastern and Western Ghâts, but also in many parts of the interior, not unfrequently capping lofty hills and plateaus to a depth of several hundred feet, often producing the dead level surfaces which constitute a striking feature in Indian scenery. Although perhaps it shows its finest development on or in the vicinity of trappean rocks, it occurs resting on rocks of all periods, occasionally far removed from any exposure of trap. It has not been observed, I believe, in any part of the Himalayas.

As a building stone, though it can hardly be called ornamental, it possesses some qualities which render it acceptable in the eyes of the natives; it is easily worked, hardens on exposure, and wears well. In the costal districts many temples, some of considerable antiquity, are built of laterite and appear to have stood well. In the Rajmehal Hills there is a small fort built of neatly cut blocks of laterite without mortar. These blocks have retained their original sharp edges.

In Midnapúr and Orissa slabs of from 4 to 5 feet long are extracted by cutting a groove round the slab above and another underneath, a few wedges are then driven into the latter, and the slab splits off. This or a nearly similar process is used for the extraction of blocks of laterite in all parts of the country where it is worked by natives.

Mr. King, in his Geology of Trichinopoli, says: "Where of poor quality, the laterite soon crumbles away when exposed to the influences of weather and moisture, as may be seen in the basement of many of the houses in the Fort of Tanjore. The laterite has there weathered away, leaving the walls perfectly honeycombed, and the layers of mortar, which are more durable, standing out as a regular net-work." In a note Mr. Foote adds: "The laterite in this case was in all probability badly selected, for in all my subsequent observations of this stone as a building material, it would appear that continued exposure to atmospheric influences, or wet, as in the case of tanks or bowries, only tends to improve the stone. Most of the religious edifices and tanks constructed of this stone show the lines and angles of the carvings as sharply as though fresh from the builder's hands."

Mr. H. Blanford also remarks: "At Andanapet I noticed some carved blocks forming part of an old and ruined pagoda the mouldings of which were as perfect as when first cut. Owing to its porous structure, however, laterite is but little fitted for fine sculpture."

Laterite has been largely used in the works in connection with the irrigation operations in Orissa. The anicut on the Kossai at Midnapúr has been altogether built of this material. The stone for these purposes has, I believe, given the engineers much satisfaction.

The Vellour anicut at Chetia-tope near Bhowagiri in the Trichinopoli district is partly built of laterite.

Dr. Balfour gives the Arcade Inquisition at Goa, St. Mary's Church, Madras, and the old fortress at Malacca, as examples of its use in the construction of buildings by Europeans.*

* *References.*

Midnapúr, Orissa, Mem. Geol. Surv., India, I, p. 277.
W. T. Blanford, on Laterite, Mem. Geol. Surv., India, I, p. 280.
H. Blanford, Southern India, Mem. Geol. Surv., India, IV, p. 206.
King, Trichinopoli, Mem. Geol. Surv., India, IV, p. 372.
Balfour, Cyclopædia, *Art. Laterite.*

X.—SLATES.

For building purposes, more particularly for roofing, slates have not been much used in India, except in some of the stations of the North-West Himalayas. This is probably due to two causes, the first and principal being that in the oriental style of flat-roofed architecture which is generally adopted for British buildings in India, slates could be only partially employed, and in the alluvial districts their place is amply filled by tiles.

Secondly, most of the slates known to occur in India, are either non-cleavable, or, if cleavable, retain also their laminated faces. The laminated slates are difficult to work into sufficiently thin layers, and are not much used, as an undue amount of timbering becomes requisite to support the weight of slates of this character.

At Dalhousie there are some large quarries in which there are slates and schists of various qualities. The best are said to be much more schistose than Welsh slates, still they are readily fissile, can be easily dressed, and can be obtained of considerable size. The fissile plains are in this instance parallel or nearly so to those of lamination.

The slates in use at Simla* are, according to Mr. Medlicott, distinctly laminated, and in every way inferior to those obtained along the flanks of the Dháoladhár, and which are used at Dalhousie and Dhurmsala.

Slates, the qualities of which are not so well known, are also obtained at Ferozpúr, Páli, Chimnawar, and Sonah, all in Gurgáon, and at Attock, Abbotabad, and Spiti.

At Chitéli, in Kumaon, occurs a slate which it was proposed to employ for roofing purposes at Ranikhet and other places. Mr. Hughes, comparing this slate with the Welsh standard, writes: "It differs from the latter in splitting along the lines of lamination instead of the planes of cleavage. It is coarser in texture, more silicious (sandy), heavier, and has a duller ring on being struck." The supply is ample for all possible requirements, and slabs of a foot square, ¼ of an inch thick, can be obtained easily.

In the submetamorphic rocks (Bijaur series) of Chota Nágpúr slates not uncommonly occur. In these the fissile planes are for the most part those of lamination. In Mánbhúm I met with a bed, however, which had most distinct cleavage structure, but there was also a tendency to split along the layers of lamination; thus, this rock breaks up into regular prisms at the surface, but it is not impossible that a good slate might be obtained, as the material is compact and dense.

In Chaibassa the school-boys have only to run down to the stream near the town to obtain a new slate for doing their sums on.

In the Karakpúr Hills, near Monghir, slates have been extracted.

The demand for slate is so small in Calcutta that I do not think it probable that these slates will ever be quarried to any large extent.

In the Champanir beds between Soorajpúr and Jumbooghora, north-east of Baroda, there are some slates which, as far as can be judged from their appearance at the surface, are considered promising by Mr. Blanford.

In the Bijaur series near Bágh there are also slates which are not so fine grained as the preceding, but some of which might perhaps answer for roofing purposes.

* Some of the slates which have been used at Simla for roofing temples are said to have lasted for hundreds of years.

Clay-slates occur both in the Kadapa and Karnúl formations in Madras; but though thin slabs can be obtained, they are not suited for roofing purposes, and where harder and more durable stone is obtainable their employment for flagging is not recommended.

References.

Powell, Panjáb Products.

Medlicott, N. W. Himalayas, Mem. Geol. Surv., India, III, p. 178.

Hughes' notes on the slates at Chitáli, Kumaon, Records, Geol. Surv., India, III, p. 48.

Blanford, Geology of Western India, Mem. Geol. Surv., India, VI, p. 217.

King, Kadapa and Karnúl formations, Mem. Geol. Surv., India, VIII, p 281

SECOND NOTE ON THE MATERIALS FOR IRON MANUFACTURE IN THE RÁNIGANJ COAL-FIELD, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

In continuation of my former paper* on the raw materials for iron smelting in the Ráníganj field, I have a few analyses of iron ore and kunkur to record which will afford a more complete series for computing their values than already exists.

Iron-ore.—The percentage of iron in several different samples of ore from various spots in the Ráníganj field has been given in the Memoirs of the Geological Survey,† but the impurities were not separately estimated. In the following analyses the amount of alumina, lime, phosphoric acid, and insoluble residue, besides the iron, is indicated; and a useful comparison can be instituted between the Ráníganj ores and those of other countries. All the samples are derived from the iron-stone measures, known geologically as the iron-stone shales group, and they were collected entirely in the western portion of the field:—

	Bagúnia No. 1.	Bagúnia No. 2.	Boldih.	Chalbalpúr.	Kúlti.	Malákolá.	Sibpúr.	REMARKS.
Insoluble	13·6	10·6	20·4	14·8	19·6	18·8	21·2	(*a*). A little magnesia and sulphuric acid occur in the Chalbalpúr, Chinákúri, and Malákolá ores. Being small, it was not quantitatively determined.
(Silica)	(11·6)	(8·6)	(16·8)	(12·1)	(16·4)	(16·2)	(17·)	
Sesquioxide of iron ...	65·44	53·2	52·28	66·45	60·4	62·92	43·82	
Protoxide of iron ...	...	13·48	1·08	...	...	...	8·92	
Alumina	6·25	4·07	5·89	4·7	5·8	3·91	5·17	
Lime...	·8	1·0	4·03	2·34	2·9	2·88	3·36	
Magnesia	·7	·85	1·8	*a*	·6	*a*	*a*	
Phosphoric acid	·71	·57	1·43	2·05	2·2	2·57	2·3	
Sulphuric acid	...	·55	...	*a*	...	*a*	*a*	
Loss on ignition ...	13·5	16·0	13·2	9·6	9·2	10·2	14·4	
TOTAL ...	101·0	100·82	100·15	98·84	100·7	101·28	99·17	
Metallic iron ...	45·80	47·72	37·43	46·5	42·28	44·03	37·60	

* Records, Geological Survey of India, 1874, Vol. VII, Pt. I, p. 20.

† Memoirs, Geological Survey of India, 1860, Vol. III, Art. 1, p. 194.

Phosphorus.—An abstract of the phosphorus contained in these samples shows that the minimum quantity is ·28 per cent., while the maximum is 1·12 per cent. :—

Bagúnia	·28
"	·31
Boldih	·62
Chalbalpúr	·89
Kálti	·95
Sibpúr	1·04
Malákolá	1·12

These results indicate that much of the ironstone might be employed for the production of iron, but that some of them are bad.

It is possible that the quality of certain beds may be regular or nearly so, in respect to the amount of phosphorus they contain, and that by selection we may avoid the use of such bands as may be unsuitable. This feature must be determined before a final opinion can be expressed on the value of the ironstones.

Proportion of iron.—The proportion of iron is much larger than that contained in the bulk of ores employed in England; and some specimens are much richer than is indicated by the foregoing analyses.*

Kunkur.—These samples were examined by Mr. Tween, showing the amount of oxide of iron, alumina, insoluble residue, water and organic matter contained in them. The minimum quantity of carbonate of lime is 54 per cent.—

	Barmúrí.	Rámnagar.	Sánktoria.
Insoluble	40·6	30·4	27·2
(Silica)	(32·8)	(23·0)	(19·4)
Oxide of iron and alumina	2·7	1·9	2·0
Carbonate of lime...	54·0	65·4	66·3
Water and organic matter	2·7	2·3	4·5

Other samples of kunkur from the above localities gave of carbonate of lime—

Barmúrí	61·1 per cent.
Rámnagar	64·98 "
Sánktoria	66·12 "

The finest specimens were since furnished by Mr. Hynd, of Báséré. They contained as much as 79·5 per cent. A few analyses (in subjoined table) placed at my disposal by Mr. Dejoux show a range from 56·94 to 78·50 per cent. of carbonate of lime, giving an average result for the entire series of analyses of about 65 per cent. With this proportion of carbonate of lime, kunkur will be quite capable of acting as an efficient flux.

	Ránigánj.	Ránigánj.	Ránigánj.	Barrákar.	Bhiokúnd.
Carbonate of lime	72·0	56·94	66·40	66·20	78·50
Carbonate of magnesia	1·30	1·72	·20	1·50	2·00
Oxide of iron	·70	1·67	3·20	2·80	2·00
Clay	23·0	30·0	27·60	22·00	10·50
Sand (free)	3·0	9·67	2·50	7·50	7·00
TOTAL ...	100·00	100·00	100·00	100·00	100·00

* A sample from the Madápúr property of the Ránigánj Coal Association yielded as much as 53·45 per cent. of iron, and laterite from the same locality gave 25·38 per cent., which is above the average for that form of ore.

Limestone.—Besides kunkur there is some impure rock-limestone near the village of Páhárpúr at the base of Panchet Hill. It is a well known bed, and is marked on the revised map of the Ràniganj field. It contains 56·43 per cent. of carbonate of lime, and varies in thickness from 12 to 15 feet. A large quantity of stone might be obtained from it, but it possesses the disadvantage of dipping at a high angle.

Calcareous nodules.—There is, in addition to kunkur and rock-limestone, another source of flux, and that is the calcareous nodules in the clay beds of the Panchet series. The average proportion of carbonate of lime was found to be 66·8 per cent. The importance of this supply is quite subordinate to the kunkur, but it is well to bear it in mind.

Calcareous concretions also occur in the Tálchír series.

Limestone beyond the field.—In reference to limestone beyond the field, I have no additional information to record regarding the stone discovered by my colleague Mr. Mallet; but I have had an opportunity of inspecting a small quantity of limestone brought from the south side of the Damúdá near Ràniganj. It looks extremely pure, and if it occurs in anything like quantity, it would be of great value.* I scarcely anticipate, however, that it will be found in abundance, and the kunkur will, in the event of any attempt to establish large iron works, probably be the flux on which to rely.

Use of kunkur in Bírbhúm iron works, 1860.—Kunkur was successfully employed in the Bírbhúm iron works, and Mr. Blanford, when reporting upon them in 1860, records as a fact that Mr. Casperz, the manager, found it advantageous to partially burn the kunkur and then to slake it, in order to separate the more impure external parts.

This process could only be advantageously applied to the more regularly concretionary varieties of kunkur, showing centrical concentration, for the ordinary form of this rock is without any distinctive purer core.

Relative quantity of ore and kunkur.—I stated in my former paper that equal quantities of ore and kunkur would be required for the production of iron in a blast furnace. In the Bírbhúm works, a less proportion of kunkur was found to be sufficient, only 3 of kunkur to 7 of ore being necessary. Charcoal, however, was the fuel then employed, whereas in my experiments, coke containing as much as 30 and 40 per cent. of ash was used, and the ore was not quite so clean. With better coke, and an ore with an average of 42 per cent. of iron, the amount of kunkur requisite would be less. In estimates of the cost of manufacture, however, it is as well to be on the safe side, and equal quantities ought to be allowed for.

Malleable iron.—For the production of malleable iron, the direct process, which, I am indirectly informed, has been quite recently perfected by Dr. Siemens, greatly improves the prospect of the undertaking in India, for the impure as well as for the purer ores. One of the chief objections made to this process by iron-masters in England, that a greater proportion of the iron passes into the slag than occurs in the present method of manufacture, does not apply to the case in India, where a saving of materials is quite a secondary consideration to that of a saving in skilled labour.

The advantage claimed for this process, of not bringing the phosphorus into combination with the iron, removes one of the most serious impediments to the development of the great advantages for iron manufacture otherwise possessed by the Ràniganj coal-field.

* Since writing the above, I have visited the locality whence the limestone was taken. It occurs as nearly pure calc-spar in small veins, striking N. and S., through a decomposed bed of gneiss. It will pay for extraction for special purposes, but cannot be looked to as a source of flux.

MANGANESE ORE IN THE WARDHA COAL-FIELD.

In connection with the question of iron-manufacture in India, it will be of interest to notice a discovery I made this year, within the limits of the Wardha coal-field, of a deposit of manganese ore, which is at present an ingredient of great service in the process for converting iron into steel, although its prime function in that process, and the presence of a certain proportion of manganese in the best steel, are questions still under discussion.

In 1869 I drew attention, in the manuscript report of my season's work, to the occurrence of manganiferous sandstone in the Kámthi series, but the proportion of manganese to the other constituents of the sandstone was altogether too small to render my discovery anything more than merely interesting. This year I was fortunate enough to meet with a much more available source of manganese, and it is this source which I wish to draw attention to.

The ore occurs in botryoidal masses in the red clays of the Kámthi series around Malágarh Hill. These concretionary lumps as usual contain much foreign matter, but the proportion of oxide of manganese is considerable. An analysis by Mr. Tween gave:

Manganese ore—

Loss on heating	8·5
Oxide of manganese	44·6
Iron and alumina	6·8
Sand and clay	40·1
TOTAL ...	100·0

The physical characters are those of psilomelane, which is a proto-peroxide of manganese; hard, having a bluish black colour, submetallic lustre, and a brownish black streak.

Of the ores of manganese this is about the most abundant. It is closely allied to pyrolusite, and by some mineralogists is considered to be only an impure variety of it.

I did not attempt to estimate the probable quantity procurable from the beds in which this ore occurs, as I wished before tracing it out closely to have its value determined analytically. I remember, however, being impressed with the idea that there was a large amount of it, of more and less purity than the sample I sent to our Museum.

None of our Indian iron-ores are known to contain more than a trace of manganese, and the independent ores of this metal seem to be somewhat scarce.

In the Panjáb it is said to come from Jammú, which may mean anywhere within the extensive Himalayan territory of the Máháráj of Kashmír.

In Madras it is said to occur near Vizianágram, in Karnúl, Maisúr, and the Nilghiris.

In Barmá, it has been reported upon by our own officers and others.

In Bombay an earthy mixture of iron and manganese oxides, occurring as a dark brown powder in magnesian limestone, was found this year by my colleague Mr. Foote, at Bhimgarh in the Belgaum district. Its composition is—

Water and organic matter	14·6
Oxide of iron and a little alumina	22·0
Binoxide of manganese	20·0
Insoluble	44·8
	101·4

The consumption of manganese ore has hitherto been very unimportant in India; but if the extensive plans now under consideration for the conversion of the pure iron-ores of Lohárá be ever carried out, we may expect a considerable demand for manganese.

THEODORE W. H. HUGHES.

Calcutta, 1st July 1874.

DONATIONS TO MUSEUM.

MAY 21ST.—Part of lower jaw of Mastodon, from the bed of the Chumbul, Dholepore. Presented by D. A. DUNN, ESQ., C. E.

Specimen of the rock from bottom of a deep well (550 feet) at Bikaneer. Presented by COLONEL MCMAHON, Hissar.

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GEIKIE, JAMES.—The Great Ice Age, (1874), 8vo., London.

GEINITZ, DR. H. B.—Dyas oder die Zechstein formation und das Rothliegende, Heft. I, (1861), 4to., Leipzig.

GILPIN, WM.—Mission of the North American People, Geographical, Social, and Political, (1873), 8vo., Philadelphia.

JUKES, J. B.—The Students' Manual of Geology, 3rd Edition, (1872), 8vo., Edinburgh.

MÖLLER, J. D.—Institut für Mikroskopie, Preisveozeichniss Mikroskopischer Praparate, (1873), 12mo., Wien.

NICHOLSON, H. A.—A Manual of Palæontology, (1872), 8vo., Edinburgh.

PHILLIPS, J. S.—The Explorers', Miners', and Metallurgists' Companion, 2nd Edition, (1873), 8vo., San Francisco.

Twentieth Annual Report of the Regents of the University of the State of New York, (1868), 8vo., Albany.

WINCHELL, PROF. A.—The Geology of the Stars, 8vo., Boston.

PERIODICALS.

American Journal of Science and Arts, 3rd Series, Vol. VII, Nos. 38—40, (1874), 8vo. New Haven.

Annales des Mines, 7th Series, Vol. IV, livr. 6, (1873), 8vo., Paris.

L'ADMINSTR. DES MINES.

Annals and Magazine of Natural History, 4th Series, Vol. XIII, Nos. 75—77, (1874), 8vo., London.

Cosmos, Vol. II, No. 1, (1874), 8vo., Torino. THE AUTHOR.

Titles of Books. *Donors.*

Geographical Magazine, No. 1, (1874), 8vo., London.

Geographische Mittheilungen, Band XX, No. 3, (1874), 4to., Gotha.

Geological Magazine, New Series, Decade II, Vol. I, Nos. 3—5, (1874), 8vo., London.

Indian Economist, with Agricultural Gazette and Statistical Reporter, Vol. V, No. 8, (1874), 4to., Calcutta.

GOVERNMENT OF INDIA.

London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 4th Series, Vol. XLVII, Nos. 311—313, (1874), 8vo., London.

LUYNES, LE DUC DE.—Voyage d' Exploration à la Mer Morte, a Petra, et sur la Rive Gauche du Jourdain, livr. 12—14, (1874), 4to., Paris.

MARTINI UND CHEMNITZ.—Systematisches conchylien-cabinet, lief. 210—224, (1872-74), 4to., Nürnberg.

Nature, Vol. IX, Nos. 229—235, & X, 236 to 240, (1874), 8vo., London.

Ocean Highways, New Series, Vol. I, No. 12, (1874), 4to., London.

Palæontographica, Vol. XIX, lief 6 & 7; XX, Abth. I, lief 1—6; Abth. II, lief 1—4; XXI, lief 1—5; XXII, lief 1—4; with supplement and atlas, (1871-73), 4to., Cassel.

PFEIFFER, DR. L.—Malakozoologische Blätter, Band XIX, XX, and XXI, Bg 1—13, (1872), 8vo., Cassel.

„ „ Novitates conchologicæ, Land-conchylien, lief 40—43.
Supple. III, lief 32—37.
„ IV, „ 9—19.
„ V, „ 1—3, 4to., Cassel.

Professional Papers on Indian Engineering, 2nd Series, Vol. II, No. 12, (1874), 8vo., Roorkee.

CIVIL ENGINEERING COLLEGE, ROORKEE.

Quarterly Journal of Microscopical Science, New Series, Vol. XIV, No. 54, (1874), 8vo., London.

Quarterly Journal of Science, No. XLII, (1874), 8vo., London.

Reports of the Mining Surveyors and Registrars for quarter ending 31st December 1873 (1874), flsc., Melbourne.

MINING DEPT., VICTORIA.

SANDBERGER, DR. F.—Die Land und Süsswasser-conchylien der Vorwelt, lief 4—10 (1871-73), 4to., Wiesbaden.

GOVERNMENT SELECTIONS, &c.

BENGAL.—Report of the Meteorological Reporter to the Government of Bengal. Meteorological Abstract for 1873, (1874), flsc., Calcutta.

GOVERNMENT OF BENGAL.

„ Report on the Revenue Survey operations of the Lower Provinces from 1st October 1872 to 30th September 1873, (1874), flsc., Calcutta.

DITTO.

BOMBAY.—General Report on the Administration of the Bombay Presidency for 1872-73, (1874), 8vo., Bombay.

GOVERNMENT OF BOMBAY.

Titles of Books. *Donors.*

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GOVERNMENT OF COORG.

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GOVERNMENT OF MADRAS.

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GOVERNMENT OF MYSORE.

" Report on the Administration of Mysore for 1872-73, (1873), 8vo., Bangalore.
DITTO.

N. W. PROVINCES.—Report by the Board of Revenue on the Revenue Administration, North-Western Provinces, for 1872-73, (1874), fisc., Allahabad.
GOVT. OF N. W. PROVINCES

TRANSACTIONS OF SOCIETIES, &c.

ALBANY.—COLVIN, V.—Report on a topographical survey of the Adirondack Wilderness of New York, (1873), 8vo., Albany.
THE AUTHOR.

BERLIN.—Abhandlungen der könig. Akad. der Wissens. zu Berlin, (1804-71), 4to., Berlin.

" Monatsbericht der konig. Preuss., Akademie zu Berlin, January—April, (1874), 8vo., Berlin.
THE ACADEMY.

" Zeitschrift der Deutschen Geologischen Gesellschaft, Band XXV, heft 3, (1873), 8vo., Berlin
THE SOCIETY.

BORDEAUX.—Actes de l'Académie des Sciences, belles lettres et arts de Bordeaux, Vol. I—XI, (1839-49), 8vo., Bordeaux.

BOSTON.—Memoirs of the Boston Society of Natural History, Vol. II, pt. II, Nos. 2 & 3, (1872-73), 4to., Boston.
THE SOCIETY.

" Proceedings of the Boston Society of Natural History, Vol. XIV, pp. 225—end, & XV, pts. 1—2, (1872), 8vo., Boston.
DITTO.

BUENOS AIRES.—Annals del Museo Publico de Buenos Aires, pts. 1—9, (1864-71), 4to., Buenos Aires.

CALCUTTA.—Archæological Survey of India: Report for 1871-72, Vol. IV, (1874), 8vo., Calcutta.
HOME DEPARTMENT.

" Journal of the Asiatic Society of Bengal, New Series, Vol. XLIII, pt. I, No. I, & pt. II, No. I, (1874), 8vo., Calcutta.
THE SOCIETY.

" Proceedings of the Asiatic Society of Bengal, Nos. 2—5, (1874), 8vo., Calcutta.
DITTO.

" Journal of the Agricultural and Horticultural Society of India, New Series, Vol. IV, pt. 2, (1874), 8vo., Calcutta.
DITTO.

" Records, Geological Survey of India, Vol. VII, pt. 2, (1874), 8vo., Calcutta.

Titles of Books. *Donors.*

CAMBRIDGE MASS.—Memoirs of the American Academy of Arts and Sciences, New Series, Vol. IX, pt. 2, (1873), 4to., Cambridge.

THE ACADEMY.

„ Proceedings of the American Academy of Arts and Sciences, Vol. VIII, pp. 409—504, (1872), 8vo., Cambridge.

DITTO.

„ Proceedings of the American Association for the advancement of Science, Vol. I—XIII, (1849-60), 8vo., Cambridge.

COPENHAGEN.—Mémoires de l'Académie Royale de Copenhagen, 5th Series, Vol. X, Nos. 3—6, (1873), 4to., Copenhagen.

THE ACADEMY.

„ Oversight over det kongl. d. videnskabernes Selskabs, No. 1, (1873), 8vo., Copenhagen.

DITTO.

DIJON.—Mémoires de l'Académie Impériale de Dijon, 2nd Series, Vol. XI, (1864), 8vo., Dijon.

GÖTTINGEN.—Abhandlungen der könig. Gesells. der Wissenschaften zu Göttingen, Band XVII, (1872), 8vo., Göttingen.

THE SOCIETY.

„ Nachrichten von der k. Gesellschaft der Wissenschaften aus dem Jahre 1872, (1872), 8vo., Göttingen.

DITTO.

KÖNIGSBERG.—Schriften der könig. Physik.-ökon. Gesellschaft, Jahg. I; II, Abth. 1 & 2, & III Abth. 1 & 2, (1860-63), 4to., Königsberg.

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles, 2nd Series, Vol. XII, Nos. 70 & 71, (1873), 8vo., Lausanne.

THE SOCIETY.

LONDON.—British Museum—Gray, Dr. J. E.—Hand-list of the Edentate, Thick-skinned, and Ruminant Mammals in the British Museum, (1873), 8vo., London.

BRITISH MUSEUM.

„ Journal of the East India Association, Vol. VII, No. 3, (1874), 8vo., London.

THE ASSOCIATION.

„ Proceedings of the Literary and Philosophical Society of Liverpool during 1872-73, No. XXVII, (1873), 8vo., London.

THE SOCIETY.

„ Proceedings of the Royal Geographical Society, Vol. XVIII, No. 1, (1874), 8vo., London.

DITTO.

„ Proceedings of the Royal Institution of Great Britain, and List of Members, 1873, Vol. VII, pts. I & II, Nos. 58 & 59, (1874), 8vo., London.

THE INSTITUTION.

„ Proceedings of the Royal Society, Vol. XXI, Nos. 147—150, (1873-74), 8vo., London.

ROYAL SOCIETY OF LONDON.

Titles of Books. *Donors.*

LONDON.—Quarterly Journal of the Geological Society, Vol. XXX, pt. I, No. 117, (1874), 8vo., London.

THE SOCIETY.

MELBOURNE.—Geological Survey of Victoria—SMYTH, R. B.—Report of Progress, (1874), 8vo., Melbourne.

THE SURVEY.

MOSCOW.—Bulletin de la Société Impériale des Naturalistes de Moscou, 1863, Nos. 1—4, and 1873, No. 2, (1863 & 1873), 8vo., Moscow.

THE SOCIETY.

MÜNCHEN.—Abhandlungen der Math-phys. classe der k. b. Akad. der. Wiss. zu München, Band XI, Abth. 2, (1873), 4to., Munchen.

THE ACADEMY.

„ Sitzungsberichte der Math-phys. classe der k. b. Akad. der Wiss. zu Munchen, 1872, heft 2 & 3, 1873, heft 1 & 2, (1872-73), 8vo. München.

DITTO.

„ Annalen der könig,Sternwarte bei München, Band XIX, (1873), 8vo., München.

DITTO.

„ Der Antheil der Entwickelung der Electricitats, lehre, (1873), 4to., München.

DITTO.

„ DÖLLINGER, J. VON.—Rede in der öffentlichen sitzung der k. Acad. der Wissens, am 25 Jule, 1873, (1873), 4to., München.

DITTO.

„ Verzeichniss der Mitglieder der k. b. Akad. der Wissens., (1873), 4to., München.

DITTO.

PHILADELPHIA.—Journal of the Franklin Institute, 3rd Series, Vol. LXVI, Nos. 5 & 6; LXVII, Nos. 1 & 2, (1873-74), 8vo., Philadelphia.

THE INSTITUTE

ROME.—Bollettino R. Comitato Geologico d' Italia, Nos. 1—4, (1874), 8vo., Rome.

GEOLOGICAL SOCIETY OF ITALY.

SALEM.—Bulletin of the Essex Institute, Vol. IV, Nos. 1-12, (1872), 8vo., Salem.

THE INSTITUTE.

ST. PETERSBURG.—Bulletin de l'Académie Impériale des Sciences de St. Petersbourg, Vol. I—VI, (1860-63), 4to., St. Petersburg.

STRASBOURG.—Mémoires de la Société des Sciences Naturelles de Strasbourg, Tome VI, livr. 2, (1870), 4to., Strasbourg.

TORONTO.—Canadian Journal of Science, Literature, and History, New Series, Vol. XIV, No. 1, (1873), 8vo., Toronto.

THE CANADIAN INSTITUTE.

VIENNA.—HAUER, F. RIT. VON.—Geologische Uebersichts karte der Oesterreichisch—ungarischen Monarchie, Blatt, Nos. 4, 7, 8, 9, 11 & 12, (1869-73), 8vo., Wien.

THE VIENNA INSTITUTE.

Verhandlungen der k. k. Zool. botanischen Gesellschaft in Wien, Band XXII, (1872), 8vo., Wien.

Titles of Books. *Donors.*

WASHINGTON.—Report of the Commissioner of Agriculture for 1871-72, (1872-73), 8vo., Washington.

DEPT. AGRIC., U. S. A.

„ United States Geological Survey—COPE, PROF. E. D.—Synopsis of New Vertebrata from the Tertiary of Colorado obtained during the summer of 1873, (1873), 8vo., Washington.

F. V. HAYDEN.

„ United States Geological Survey—GANNETT, H.—Miscellaneous Publications. No. 1, Lists of Elevations in that portion of the United States west of the Mississippi River, (1873), 8vo., Washington.

DITTO.

„ United States Geological Survey—GANNETT, H.—Miscellaneous Publications. No. 2. Meteorological Observations during 1872 in Utah, Idaho, and Montana, (1873), 8vo., Washington.

DITTO.

WELLINGTON.—Transactions and Proceedings of the New Zealand Institute, Vols. IV and V, (1872-73), 8vo., Wellington.

WIESBADEN.—Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau, heft I—XXIV, (1844-70), 8vo., Wiesbaden.

ZÜRICH.—Neujahrsblatt von der Naturforschenden Gesellschaft auf das Jahr., 1873, No. 75, (1873), 4to., Zürich.

THE SOCIETY.

„ Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, Jahrg. XVII, heft 1—4, (1872), 8vo., Zürich.

DITTO.

„ Nouveaux Mémoirs de la Société Helvétique des Sciences Naturelles, Band XVII—XXIV, (1860-71), 4to., Zürich.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1875. [August.

THE SHAPUR COAL-FIELD, WITH NOTICE OF COAL-EXPLORATIONS IN THE NARBADA REGION, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

I.—NOTICE OF RECENT EXPLORATION.

The question of the coal-supply in the Narbada valley has now been for long before the public, and is still unsettled. Mohpani is still the only locality where workable coal is known to occur; and the extension of the coal here is as yet unproved. Since December 1872, explorations have been carried on in several places under the orders of Government, but so far without result. The region to which these remarks apply is the northern portion of the great Satpura basin of the coal-bearing rocks, within comparatively easy reach of the Great Indian Peninsula Railway. It has long been known that there are numerous outcrops of coal along the south margin of the field; but the distance would greatly add to the cost of exploitation. To that ground, however, we must have recourse if our endeavours to find coal in a more favorable position prove unavailing. With this in view, a survey was made during the past season of the western and more accessible portion of the southern region, known as the Betul or the Shápur coal-field.

Before proceeding to describe this field, with the aid of the annexed outline-map, I would give a sketch of the explorations up to date. It cannot be said that any of the experiments has proved a failure, because no one of them has attained the full limit contemplated for the search. No success, however, can be reported as yet; and in one case some disappointment has to be recorded. Having had the entire responsibility of choosing the positions for the trial borings, I am, of course, anxious, for the satisfaction of Government, that a right understanding should exist of the grounds upon which I decided: it is so easy after the fact to condemn a project as hopeless; and there are always people ready to take the credit of wisdom on such occasions. The data available were never more than could warrant a fair possibility of success, as was duly explained at the first.

The regular mode of proceeding in this investigation would have been to explore the measures at Mohpani—to see how the coal-seams behave on this side of the basin to the deep of their only outcrop. Information might thus have been gained giving some grounds for a definite opinion as to the position and depth of the coal elsewhere along this region. This course was not available, the ground being in the possession of the Narbada Coal Company. The interests of this colliery depend largely upon the conditions in question; but as yet little or no light has been thrown upon them—no coal has up to date (June 1875) been found beyond the limits of the faults against which the original working stopped.

Thus the attempt that had to be made was not that of exploring a known coal-field, but to look for the coal-measures in a great series of formations where it was known they might occur. The explorations proposed were of two kinds: one depending upon the unknown limits of the rock-basin itself; the other upon the unknown lie of the coal-measures within the known area of the basin.

Exploration in the open valley of the Narbada.

So far as appears on a geological map, the northern limit of the rocks with which the coal-measures are associated would approximately correspond with the slightly irregular line indicating the southern edge of the alluvial plains. Along certain portions of that line narrow outcrops are seen of metamorphic rocks; and where these appear, the continuity of the younger rock-basin is, of course, cut off. There are, however, wide gaps where no older rocks appear, where the valley-deposits rest against the coal-bearing formations. It was for a time supposed that the junction of the sandstones with the metamorphic rocks occurred along a great fault, by which the newer rocks were thrown up to the north and removed. Were this so, we should be entitled to draw a fixed fault-boundary to the possible coal-bearing ground across those gaps between the existing outcrops of the metamorphics. From a careful study of the rock-junction where seen, I came to the conclusion that no great line of dislocation could be proved: the actual contact of the two rock-series was almost everywhere found to be the original one. I even got remnants of the younger strata on the north flanks at the same level as on the south of the narrow ridges of metamorphics. It thus becomes apparent that the gaps in the present boundary, where the alluvium laps against the sandstones, may only represent bays in the original edge of the basin of deposition of the coal-bearing formations. A full discussion of this question is given in my last report upon this ground; it can only be by a revision of that discussion that the exploration for coal in these blank areas can be shown to be unwarranted.

The Mohpani colliery, on the Sitariva, lies in the centre of one of the longest of these blank portions of the boundary. Almost the last rock seen in the river is the coal, in full strength, underlying steeply towards the plain. An attempt was made to work the coal here, but it was found to be too much broken and crushed to be worth extracting. It was to the north of this position that I recommended borings to be made in the alluvium, close to the branch railway, where coal, if found, would be very favorably situated. There were of course, other doubtful conditions besides the principal one already indicated: the bay may have been there, and yet the coal deposits have found small place in it: or whatever had found place there may have been to a great extent cleared out by the excavation of the hollow in which the alluvium now lies. The probability, such as it is, of coal existing under any considerable portion of the immense area covered by the alluvium seemed sufficient to warrant some outlay upon the search. Boring was attempted at Gadarwara station and at Sukakheri, at ten and four miles from the boundary. The former trial broke down at a depth of 261 feet. The hole at Sukakheri was carried to a depth of 491 feet, yet without piercing through the valley deposits. Both these trials were started when boring implements were deficient; and although I gave 500 feet as a possible thickness for the alluvium, I certainly expected rock to be struck at a less depth; thus the borings were not begun on a sufficient scale for such a depth where piping had to be used throughout.

There was nothing whatever for a positive opinion that the superficial deposits would be so deep. The Narbada flows on the north side of this broad plain; and within comparatively short distances throughout its course it touches rock, leaving the valley through a narrow rocky gorge 100 miles to west of, and at a level about 200 feet below, the surface at Gadarwara. This gorge is the lowest lip of the rock-basin of the actual valley; for the watershed on all sides is on rock. We have thus at least learned from this Sukakheri boring an interesting geological fact regarding the depth of the pleistocene valley.

A complete prognosis of the case would involve also the consideration of yet another, great valley of excavation in the same area, but regarding which our information is still more obscure. The valley occupied by the pleistocene deposits was to a great extent cut out of the great trappean formation, which had filled up a previous valley to the full level of the highlands on the north and south. Both to east and west of the Sitariva bedded trap is, at several places, the last rock seen passing under the alluvium at the south side of the valley. Locally, too, it is underlaid by thin fresh-water deposits supposed to be of upper cretaceous age. That pre-tertiary valley to some extent corresponded with the existing feature, being principally bounded by the Vindhyans on the north and the Mahadeva hills on the south; but it is improbable that its line of discharge was the same as that of the present Narbada. Regarding its possible relative depth there is no certain clue; but there is nothing to suggest its having been great in the Sitariva region, older rocks being seen at many places to east and west. There were some symptoms that the boring at Sukakheri was approaching a bottom of this kind; the last samples of clay brought up were much charged with granules of iron oxide as if from a lateritic layer which is frequently found coating the trap.

The discovery of the great depth of the surface-deposits at Sukakheri is, no doubt, a check to our hopes of finding the coal-measures within easy reach in this neighbourhood, and may therefore divert the press of exploration to other points; but, of course, the question of the existence or not of the coal-bearing rocks in this position is quite untouched. The argument on this point stands just as at the beginning; and unless before long coal is found under more favorable conditions elsewhere in this Satpura region, I would certainly recommend the prosecution of the search here. The actual position might be shifted to Gagarola, a village a mile and a half south of Sukakheri. I went clear to the north in first choosing a site, to avoid coarse gravels in the covering deposits near the hills, and to get well beyond a known region of disturbance in the coal rocks, should they be found.

Exploration in the hill-region.

The other class of exploration is directed to find the coal-measures within the known rock basin. On the south side of the basin the outcrop of the measures is nearly continuous from east to west. The hope of finding them on the north side is based upon the single outcrop on the Sitariva, and upon the fact that very generally they are closely associated with the Talchirs, and these are found at several places along the north boundary. The reasonable conjecture is, that the coal may be more or less continuous throughout the whole basin, beneath the covering Mahadeva rocks. For a short distance west of the Sitariva the Talchir rocks, and even the coal-measures, are traceable; their manner of disappearance in this direction is not seen; the nearest section is very obscure and greatly affected by trap dikes.

In the first complete section exposed, in the Dudhi and east of it, younger rocks occupy the whole ground up to the boundary with the metamorphics. When next the lower members of the series come to the surface along the boundary, the Talchir group alone is found, overlaid by younger rocks than the coal-measures, the latter being completely cut out, or 'overlapped.'

In explorations of this nature it is commonly the case that some approximation can be made towards computing the depth at which the object should be attained. The simple general rule is—from the proposed point of experiment to follow the descending section directly across the strata to the outcrop of the bed sought for; and then, from the surface distance and the mean dip of the rocks, to calculate the depth from the surface at the required point. Were this rule to hold good in the present case, the coal would be hopelessly out of reach where we are now seeking for it. Throughout this whole central area of the rock basin, the strata have a very constant northerly slope to within a short distance of the north boundary, where, according to the above rule, the depth to the measures would be enormous. The rule, however, works upon the assumption that the beds continue to the deep as they appear at the surface; and it is quite certain that this is not the case with the rocks we have to deal with here. They are for the most part massive, irregular sandstones; and it is demonstrated that not only individual beds, but whole groups of beds, die out to the deep and are overlapped before reaching the north side of the basin. There is no *law* known, or in the nature of the case possible, for such a mode of extinction and succession of stratified deposits. Their distribution depends upon the local physical conditions at the time of their formation, the only evidence for which conditions is to be found in the deposits themselves. Thus, there can be no reason assigned why the coal-measures themselves should not also die out to the north, they being composed of thick sandstones not unlike those above them. The hope that such is not the case rests upon the features along the north boundary, as already noticed.

The facts bearing upon this class of explorations have also been given and discussed in some detail in my last report on this ground; but from the foregoing brief remarks it can be seen that these trials, though under such very different conditions, are of a scarcely less precarious nature than are those in the open valley. It may also here be understood that any offhand opinion on the point can be of no value, unless in so far as it may be based upon reasons such as those indicated.

In selecting sites for these borings, I gave, as for the others, a wide berth to the known difficulties close to the general boundary of the field; such as, firstly, the greater disturbance of the strata, often with trappean intrusion; secondly, the coarsely conglomeritic character of the Mahadevas in this zone, which has proved so obstructive to borings at Mohpani; and thirdly, to give a better chance of getting below the known overlap. To these considerations the surface features added other inducements. On the east and west of the basin, two wide open areas are presented in the valleys of the Dudhi and the Tawa, separated from the plains of the Narbada valley by a narrow belt of low hills. If the Satpura coal-basin ever fulfils our reasonable hopes as regards coal, it is in these areas that the industry would be established, and here that it should be started. Whether or no coal should be found somewhat nearer the surface towards the edge of the basin, it would be a duty to ascertain if it lay within reach of these central areas where mining must be located if it is ever to expand; but to fulfil this purpose the borings here should be carried to the full depth at which there would be any prospect of mining being profitably carried out. Upon this point my knowledge and experience scarcely entitle me to an opinion: I should say conjecturally, that supposing coal to be present, it would pay better in the long run to work it at 150 fathoms in the centre of the field than at 50 fathoms near the margin.

Dudhi Valley.

In commencing operations, preference was given to the Dudhi area, for the reason that the strongest natural outcrops of the coal both to north and south were on the east side of the basin. The borings at Khapa and Manegaon were commenced in the middle of February 1874. Both start in the Denwa horizon of the Mahadeva series. At the close of the season, on the 1st June, they had reached the depths of 260 and 242 feet. After the stoppage of the Sukakheri boring, work was resumed at Khapa and Manegaon on the 15th January 1875. On the 23rd of April work was suspended at the Manegaon boring (at 419 feet), the depth now attained necessitating the constant attention of the European foreman at one boring. At the close of the season (15th May) the hole at Khapa was down to 472 feet. The sections of these borings give as yet no hint as to the prospect of finding coal: the rocks are throughout the same as at the surface, purple and greenish clays, alternating with sandstones, either white or tinted by admixture of the coloured clays. In the Khapa hole the proportion of clays to sandstones is 193 to 279, at Manegaon it is 219 to 200. There is nothing discouraging so far. I have shown elsewhere that the Pachmari sandstone (lower Mahadeva) passes into clay to the deep; and the change to the coal-measures would probably be abrupt.

Tawa Valley.

On the representation by the Railway Department of the importance of a supply of coal as far as to the west as possible, the trials in the Tawa valley were commenced on the 25th December 1874 at Kesla, and on the 1st January 1875 at the Suktawa, under the management of Mr. A. Gardiner, M. E. The latter is entirely in strata of the Damuda formation, on the horizon of the Bijori beds as described in this region, and nine miles south of the Shapur coal-field. The Kesla boring starts in the lower beds of the Mahadevas, somewhere in the Pachmari horizon, so far as can at present be determined, four miles due north of the Suktawa boring; yet, if the structure upon which all these trials depend is favorable, if the Barakar coal-measures rise again towards the north edge of the basin, they may be nearer the surface at Kesla, which is only three miles from boundary of the metamorphics. When closed for the season (30th April) the Kesla hole had reached to 302′ 6″, that at the Suktawa to 241′. Clay greatly preponderates in the Kesla boring, a hard sandy rock variegated brown and red. The Suktawa rock also maintains the same characters as at the surface, alternations of strong sandstone with slightly carbonaceous shales. I do not find in them any grounds for a change of opinion regarding the original project; the depths as yet attained are no greater than might occur at a short distance from the outcrop.

Other trials recommended.

There is, however, already the surety from these borings that mining in this central region will have to be deeper than has yet been attempted in India. For this reason, and to provide against the by no means improbable event of failure to reach the coal-measures at all in this position, it is certainly advisable to commence trials in other ground. Two projects are open to us: to try for the measures close to the north boundary of the basin, in a position analogous to that of the outcrop at Mohpani; and, to commence the exploration of the Shapur coal-field. With this view I have selected four sites for trial borings along the north boundary: one on the road into the Dudhi valley, about seven miles west of Mohpani; one on each of the roads to Pachmari, close to patches of Talchir rocks; and one at Lokartalai. For the southern region I have selected a site near the village of Sonada. One or more of these trials can be carried on at the same time and under the same management as one of the deeper borings in each of the river valleys, say at Khapa and the Suktawa.

II.—The western extension of the Satpura basin.

The occasional mention of the probable extension of the coal-bearing series beneath the trap to the west of the known Satpura basin, and the fresh demand for coal for the new State Railway starting northwards from Khandwa, led to the request for an examination of the line of ground most likely to throw light on the possibility of finding coal in that direction. At the end of the season I made a tour to the west of Lokartalai along the direction of the north boundary of the basin. There cannot be said to be any immediate practical result, but observations have been made confirming and greatly extending the conjecture upon which the hope was based: direct evidence has been found of the underground continuation of this important series of rocks for some distance beyond the limits hitherto known; and an identification of Mahadeva rocks has been made far to the west on the Narbada near Barwai, which opens the question whether some of the so-called cretaceous sandstones along the valley of this river to near the coast may not belong to the same much older series, and thus be indicators of western coal-fields corresponding with those of the Damuda valley on the east.

No observation has hitherto been made (or at least published) of any appearance to the west of Lokartalai of rocks closely connected with the coal-bearing series. At page 43 of my last report (1872) on the Satpura basin (Mem. Geol. Sur., Vol. X) a brief notice is given of the western part of the northern boundary of the basin. The following remarks are in continuation of those there given. It was said that east of Sali the metamorphics are in force along the boundary. This was hazarded on the strength of a small outcrop at Sali, and of their forming the principal part of the range twelve miles to the east on the high road north of Kesla. I find, however, that intermediately there is an important section in which the Mahadevas are continuous to the plains. It is south of Zumáni in the Narbada valley, and north of Lálpáni in the Táwa valley. Along the base of the hills north-west of Kesla and Táko the Bágra limestone is in force, with a dip of 30° to north-north-west. The overlying sandstone and conglomerate with a low dip in the same direction form the scarp above. From the large and numerous blocks of trap at the foot of the waterfall there is probably an outlying cap of this rock on the hill. The crest of the pass north of Lálpáni is on the southern ridge of the range, on the run of the high dip, 30° to north-north-westerly, in conglomeritic sandstone overlying limestone. There is probably some slip or sudden twist along the north of this ridge, for on the sloping high ground in that direction the strong limestone is again in force, with a low north-north-westerly dip. On the rise to the outer crest of the pass the overlying sandstone and conglomerates come in again. These breccia-conglomerates are splendidly exposed in the steep gorge to east of the road. In a spur near the mouth of this gorge there is a small Mahadeo rock-temple in the conglomeritic sandstone, having a dip of 3° to north-north-west. A little below this the dip rises rapidly to 40°, in hardened sandstone distinctly overlying the conglomerates; there is then a band of crushed rock and a trap dike, but within about eighty yards apparently the same sandstones are again 30° to north-north-west, rapidly falling to 5°. The beds that come in here are peculiar: a whitish sandstone (which has been a good deal quarried), with partings of white shale and a layer of pyritous coaly shale. The character of these beds and their stratigraphical position at the top of a long ascending section of the Bágra group make it highly probable that they belong to the Jabalpur horizon, the nearest known position of which is capping Chátar hill sixty miles to eastward. When last seen in the stream under Jalpa the beds are quite flat, and end abruptly, with some crushing, trap being the next rock seen. This is, perhaps, the most important section we have of the north boundary, as it marks so clearly the upheaval of the Satpura area, or the depression of the Narbada valley, along it. It illustrates and explains some of the sections to the east, especially that on the Anjan (op. cit., p. 37).

The Zumáni section.

About six miles east of Lokartalai there is a fine section of the boundary under the scarp of Budimai ridge. South of Batki the Bágra limestone appears in force in the low ground at the base of the scarp, dipping at 30° to north-north-west, under the trap of the valley. Along the strike to the south-west of those outcrops the limestone disappears, but there is a much fuller section of this fringing zone of rocks. They form quite a flanking range outside the scarp, separated from it by a chain of small longitudinal valleys excavated along the broken uniclinal flexure,

Budimai section.

between the nearly horizontal beds of the scarp, and the same beds tilting down under the plains.* Before these beds disappear the dip flattens very much, or even slightly turns up to the north, while near the axis of the flexure it is nearly vertical. I did not here detect any characteristic Jabalpur rock, but unless faulting interferes with the sequence they ought to be represented. The fine Dandiwara sandstone, so much prized on the Great Indian Peninsula Railway, comes from the top beds of these inclined strata. Structurally this section corresponds with that of Zumáni, only the flexure is more marked. It is important to remark that in both cases the sandstones reach well to the front of the run of the nearest metamorphic rock. The strike of the latter into the anticlinal axis rather suggests that they acted as a fulcrum upon which the overlying strata were bent and broken.

The western inliers.

No special disturbance was noticed in the trap on the Moran. In passing to the west-south-west on the strike of the little rib of metamorphic limestone south of Lokartalai, at about a mile distance, there is a low ridge. A clear section of it is seen in the stream, showing it to be formed of trap, with a central band of gray and reddish clay, all having a dip of 60° to south-south-east. In the next stream there is a still better section of this continuous little ridge, just under Sálei village. The clay band here is calcareous, and is locally full of *Physa Prinsepii*, the common fossil of the intertrappean formation. The dip is the same as before. The ridge passes just to south of the village, and immediately north of it there is a strong outcrop of hard conglomeritic sandstone, about 30 yards wide, the dip being 60° to 70° to south-south-east. The trap occurs again immediately north of it. This rib lasts for about a mile, the intertrappean band being traceable much further. In the Ganjál at Uskali, and exactly on the same strike, there is a stronger outcrop of the same sandstone. It has been extensively quarried in the little hill east of the village. The dip here is 45° to south south-east, and in front of it the trap is well seen, although the beds are massive, to have the same dip, gradually lowering to 5° at half a mile up stream. The intertrappean band is absent in this section. Immediately below the sandstone there is a small obscure section of trap. Two miles further, on the same exact strike, at Kupási and Jinwáni, the rib of sandstone appears again, still at 60° to south-south-east, and just under it at Kupási there is a small crop of metamorphic limestone. This is the last appearance of the sandstone, at eleven miles from Lokartalai. The structural feature, however, is well marked for a much greater distance, and exactly on the same strike: south of Padarmati there is an outcrop of intertrappeans still at 50° to south-south-east; in the streams at Káthmákhera and Singanpur, and better still in the Máchak above Magardha, the zone of high dip in the trap is well seen. Beyond this it seems to die out, being scarcely noticeable in the Siáni below Makrai. Magardha is twenty-five miles from Lokartalai.

Interpretation of them.

The feature just described is a very remarkable one. The sandstone of these inliers would seem to belong to the Bágra rocks; it is quite like the rock found near the metamorphics all along the boundary. It is the structural feature that exhibits such a change. Even this might have been anticipated in kind: the steady south-westerly dip of the sandstones on the Moran indicates a depression of the formations in that direction; but it was not there detected that the trap participated in that disturbance. This fact comes out very forcibly from these western sections; and they give one, too, an idea of the magnitude of the event. For a thickness of quite 1,000 feet the trap affects the same steep dip as the sandstones, which must, one would think, carry the latter to at least that depth in the ground to the south. This, of course, would put the chance of coal indefinitely out of reach in this immediate region; the horizontal extent of the feature being quite in proportion to the vertical magnitude. The geological reading of it is very puzzling, especially when it has to be taken from such scattered observations as can be made during a single march across the ground. I can only state the puzzle as it stands. The extraordinary straightness of the feature compels one to consider it as possibly connected with faulting. In this connection especially these western outcrops must be taken as solidary with the rest of the boundary to the east; for the disappearance of the sandstones on the Budimai and Zumáni sections is exactly on the same line. The great contrast, however, in the features of the cross-sections to east and west makes it especially difficult to connect both with one and the same master-dislocation.

Whether faulted.

Apart from the fact of remarkable continuity and straightness, the *primâ facie* suggestion of faulting is the same in the east as in the west of the line. The abrupt termination, with especial crushing, of the flat sandstones at the north end of the Zumáni section, with trap at a lower level close-by in front, is strongly suggestive of faulting with northern downthrow; the only other explanation being the pre-trappean origin of the edge of sandstone. Similar close vertical juxtaposition of formations occurs to the west: trap is found close to the north of the sandstone outcrops, and at a lower level, at Sálei and Uskali, suggesting the same northern downthrow, or else pretrappean exposure. The rock itself of the western outcrop does not suggest any difference of throw east and west. Nor is there any excuse for placing the fault (if there is one) between the sandstone and the metamorphic limestone at Kupási: the sandstone seems to be of the same horizon as that occurring at the same level east of the Moran,—a breccia conglomerate, such as is found in natural contact with the metamorphics all along the boundary; and at the Moran this ridge of supporting rock strikes into the axis of the Budimai flexure, well to the south of the supposed fault-line. Thus from this more direct portion of the evidence, one must, I think, conclude that if there is a fault it is post-trappean, and has a southern upthrow throughout. The collateral evidence, with reference to faulting, presents, on the contrary, a great difference between the eastern and the western areas. The proof of a great post-trappean southern depression by flexure at the edge of the stratigraphical basin to the west of the Moran is now beyond question. This, though perhaps not incompatible with a southern upthrow by faulting along the north boundary of the same area, certainly does not seem to agree with that supposition. The evidence of elevation, by flexure along the same line of disturbance of the area to the east of the Moran seems equally clear, and this would remove the necessity for upthrow by faulting along the northern boundary, though not incompatible with the co-operation of such a feature. The certainty of the post-trappean age of the western depression might afford presumption that the elevation to the east was of the same age, opposite effects in adjoining areas being rather the rule than otherwise in crust movements; but I shall presently in this paper call attention to the evidence of extensive disturbance and denudation of the Mahadeva and underlying series prior to the outflow of the trap. The fact, as I said, is a very important one; and if it is established at one point on a geological horizon, it must be taken some account of throughout.

III.—Possible coal-fields on the Lower Narbada.

The Barwai area.

Finding myself at Khandwa, after a vain attempt to discover any further sign of the infra-trappean formations along the Satpuras, I devoted a few days to visiting Barwai, where so many different rock-series are represented within a small area. A combination of favorable circumstances, due to the works of the Holkar State Railway now in active progress, put it in my way to add another to the list of geological attractions of this ground.

The Mahadeva horizon.

When the general description of the western Narbada region was published in 1869 (Memoirs, Geological Survey, Vol. VI, pt. 3), the original conception of the Mahadeva formation—that it was quite unconformable to, and independent of, the coal-bearing rocks of the Damuda series, and superior even to the

Rajmahals—had not been rectified. Mr. Blanford accordingly, in correlating the groups of the lower with those of the upper Narbada valley (which he had not seen), affiliated the Lameta, and with it the Mahadeva beds of the latter, to the cretaceous horizon of the former area. This view has been so far upheld as regards the Lameta group; but in November 1872 (Records, Geological Survey, Vol. V, p. 115), the correction was pointed out as regards the Mahadevas. In making so important a change it might have been thought better to adopt a new name, but if that were done the correction would not have been so apparent—the old name would have held on in its false connection. Besides, the correction was made in the typical area: the Pachmari (Mahadeva) sandstone is now known to hold a middle horizon in a continuously superposed series, of which the Jabalpur (Rajmahal) group is the uppermost, and the Talchirs the lowest member. The original Mahadeva ground contains four well marked groups (Jabalpur, Bágra, Denwa, Pachmari) forming the present Mahadeva series.

True Mahadevas at Barwai.

The correction just quoted led, of course, to the view that there were no Mahadevas in the lower Narbada area; that all the infra-trappean strata there either belonged to, or were closely connected with, the much younger cretaceous group of Bágh. The observation I have now to bring to notice is that there are true Mahadevas at Barwai, unconformable to the cretaceous beds of that place. The proof of this discovery is due to Mr. Moore, one of the engineers at the railway viaduct on the Narbada. Mr. Moore has charge of the great quarries opened at Gatta, on the upland east of Barwai, on the banks of the Choral, and to which a temporary railway is laid from the viaduct. In the bottom of a small valley, about a quarter of a mile north of his bungalow, Mr. Moore discovered a number of fossil oyster shells in a shallow water-course. The ground being quite flat there was no section; so at my request Mr. Moore had a shallow pit sunk, and has sent me the following description:—

"1' 6"	entirely of oyster shells.
9"	Thin bed of conglomerate with fossils imbedded.
3' 3"	Bed of soft white sandstone; first foot excavated with a pick; the rest harder and distinctly stratified with perfectly level beds.
4' 6"	Thick bed (bottom not reached) of water-worn pebbles and small boulders imbedded in stiff yellowish-brown clay or loam."

From this spot, by sinking shallow pits, Mr. Moore traced the fossil-bed (without getting to the end of it) to within 400 feet of the scarped upland, about 80 feet high, formed of the massive sandstone in which quarries are opened over a very large area. It is a hard white rock with red streaks and mottling. Pebbles (chiefly of Vindhyan quartzite) are scattered through it locally so as to form a conglomerate; but even in the clearest sections in the quarries no regular bedding is visible, the strings of pebbles, however, indicating that the mass is undisturbed. Well marked joint-planes traverse it in various directions. It is a thoroughly consolidated rock, though portions of it are much harder than others through infiltration of silica from the once superincumbent trap. No earthy layer is found in it; and along the Choral it is seen resting directly on the nearly vertical Bijawar limestone and breccias.

One could scarcely desire a more distinct case of a wide geological break than is presented in this section: the petrographical contrast is evident enough from the foregoing description, suggesting in the strongest manner the necessary distinction of the formations. The case for unconformity may not be considered conclusive: a small fault between the oyster bed and the scarp to east of it would account for the actual relative positions; a concealed sharp curve in the bedding would have the same effect; or even it might be an original great bank of sand with the muddy oyster bed alongside of it. Nothing short of an artificial cut across the rocks could finally dispose of all these objections; but certainly the first and most probable explanation is that of original denudation-unconformity. The incompatibility of the even approximate contemporaneity of such rocks as these now are, indefinitely increases this probability.

The oyster bed and its associates are characteristic representatives of the Bagh beds of this region. All the petrographical characters of the Gatta rock point to its being a representative of some member of the Mahadeva series of Central India. I failed, owing to the Huli festival, to get to the larger area of similar rocks about Kátkot. I suspect the great quarries opened there for the works on the ghât are in the same rock as at Gatta.

Inference as to coal.

The observation I have just explained has a very direct bearing upon the object of my trip westward—the possible extension of the coal-fields. It has not been sufficiently noted that the resemblance of the massive sandstones of the lower Narbada valley, especially in the Deva valley close to the alluvial plains of Broach, as repeatedly observed by Mr. Blanford, is a permanent character, and would hold true whatever geological rearrangement the original Mahadeva group might undergo; also, that the connecting of those rocks with the overlying cretaceous beds is given with great doubt by Mr. Blanford, more because he had not detected any break between them, than from any dependence upon their apparent conformability. This missing link of evidence has now been found, and Mr. Blanford's original conjecture confirmed. It is certain that at least some of the rocks in the Western Narbada area provisionally placed with the cretaceous formation are not only lithologically like the Mahadevas, but are stratigraphically related to the cretaceous beds just as the Mahadevas of the eastern area are to the Lametas. There is scarcely much risk in supposing that the sandstones of the Deva valley are the same as the Gatta rock; and if so, the position of the Mahadevas as now understood would give a new significance to the fact, suggesting very directly the possible or even probable occurrence of the coal-measures. It is not for a moment supposed that there are outcrops of the Damudas in the Deva valley; and no probable guess can be made as to the depth at which they are likely to lie; 2,000 is as likely as 500 feet.

The prospect would include the neighbourhood of Burwai. No doubt the rock at Gatta rests immediately on metamorphics; but there are like overlaps of the Mahadevas in their typical area. The Kátkot outlier is also very likely to be shallow. I saw, however, at the viaduct a quantity of cut stone of the same description from a place near Akhund, to the south-east. It is possible this may be the lip of the basin from which Gatta is an overlap, and that coal may be within reach. Of its great value in such a position I need not remark. I had sent my camp by forced marches to Bankeri railway station, and had no means of going about, having already overtaxed the hospitality of the local officers.

A general consideration of the case does not discourage these suggestions. The great Satpura basin almost certainly had its outlet to the west. Its uppermost strata spread out to the east over the gneiss at the watershed of the peninsula. It is not unreasonable to suppose that to the west as to the east of India an expansion of the lower coal-bearing groups took place towards the sea-board, and that the Bengal fields may have underground equivalents in the region of the lower Narbada.

IV.—The Shapur Coal-field.

Position.

In the event of failure to find coal, and in sufficient quantity, on the north side of the Satpura basin, the alternative will be to take up the most accessible position on the southern outcrop of the measures. In anticipation of this necessity, a survey has been made of that portion of the ground where such trials should be commenced. Throughout the whole length of the basin from east to west, the Barakars are exposed in a more or less continuous outcrop. On the east, where unfortunately the coal is in much greater force, the position is quite out of reach of present demand in an upland valley of the Pench river, which is a tributary of the Wein Gunga, which, as the Prenhíta, is an affluent of the Godavery. The head waters of the Tawa adjoin those of the Pench; but they fall rapidly to a much lower level, flowing at first in deep gorges, which soon open out into broad undulating plains. This broad valley of the Tawa, though containing some large patches of flat alluvial land, is for the most part barren, rocky, and uneven. The high road between Hosungabad and Betul crossing it from north to south is decidedly a rough one.

Map.

The annexed map represents a portion, about twenty miles long, on the southern and western borders of this valley. It is taken from sheets 6, 7, 12, and 13 of the Topographical Survey. The topography is very far from being as accurate as is required for close geological work, but for present purposes it will suffice in the hands of any one in the least fitted to look after coal. The boundaries of the coal-measures are about as close as the transitional character of the formations admits of. The other geological features are accurate so far as given, but a good deal remains to be done in the way of following out trap dikes, quartz reefs, and like details.

General characters of groups.

The first thing to be done is to indicate what rocks constitute the coal-measures, or in a wider meaning, the Barakar group. Coal and carbonaceous shale are seen to be confined to a special line of country; but it soon becomes apparent that the rocks containing them are not constantly separated from the adjoining rocks by any sharply defined features, that in fact, the measures only form a zone, horizon, or group, in a closely connected stratigraphical series. The demarcation of fixed boundaries thus becomes a matter of much difficulty, and must be accepted subject to correction. In the absence, or very rare occurrence, of fossils, the problem has to be worked out conditionally from lithological and stratigraphical data.

The whole rock-series is composed exclusively of sandstone and clays, the former greatly preponderating, except at the base. The character of the bedding throughout is massive, and, as is then generally the case, irregular. It is only in the most general way that either rock can be said to prevail in any particular zone. There are, however, some types of composition and of texture more or less characteristic of different portions of the series, and it is upon these that the discrimination of the several groups in a great measure depends. Throughout a great thickness of strata at the base the sandstones are very fine-grained and of a pale greenish-yellow tint; the clays are hard, splintery, and silicious; both often enclose large erratic blocks and other débris, forming coarse conglomerate, generally with a large preponderance of matrix. These beds form the Talchir group. Above this comes the coal-bearing zone, the Barakars; in which the sandstone is generally white, somewhat coarse and gritty; the clays being shaly and carbonaceous. The sandstone of the next overlying band of the Motur horizon is softer than that of the coal-measures, more earthy and of mixed composition, and having corresponding gray, brown, and greenish tints; the clays are lumpy, sandy, and ochrey. The distribution and the relations of these groups will appear from the description of the local sections.

Conditions of disturbance.

The difficulty of demarcating the several formations is much increased by the disturbances that have affected the whole series, producing intricacies in the boundaries very troublesome to make out where the primary characters of the groups are so undecided. The dips are not often high, but they vary much; and faults are numerous, some having a great throw. There are also many trap dikes and quartz veins or reefs. These are seldom connected with actual dislocations of the strata, but they often disguise the mineral characters of the rock, and thus obstruct the identification of isolated outcrops.

The southern boundary.

The south boundary of the area under notice is the base of the sedimentary series,—the junction of the Talchir group with the gneissic and schistose rocks forming the highland of Betul. For the most part the contact occurs in the low ground along the base of the hills of crystalline rocks. It forms an exceedingly indented outline, being in fact the intersection of two very irregular surfaces—the present ground surface with that of the original floor of deposition of the Talchirs. The actual contact is frequently exposed; nowhere better than in the Phopás (at the south-east corner of the map): the gneissose schists are denuded in the bed of the river, and for several score yards along the left bank the Talchir boulder clay is seen resting flatly on a rough, sharply weathered, ancient surface. At some points this boundary seems to be a faulted one, as in the section of the Amdhana stream at the south base of the Bhaorgarh ridge; the contact here is very steep and crushed, and is moreover on the run of the Machna, north-east to south-west, fault. In the west, at the head of the Bhoura and Súki valleys, the Talchirs rise to a considerable height, forming the upland about Kota, between the Bhaorgarh crystalline ridge on the south and the basalt-capped ridges on the north. The formation is splendidly exposed in the scarps of this small plateau, west of Mura village. The exact position of the south boundary has only been fixed at a few points of our area; the intermediate portions being left uncoloured in the present map.

Northern limit of map.

The northern limit of the area to be described is an arbitrary line in the great sandstone deposit overlying the coal-measures. These beds belong to that middle portion of the Damuda series of the Satpura basin indicated in my former paper as the Motur horizon, in which carbonaceous matter seems to be altogether wanting (but reappearing in the overlying beds of the Bijori horizon). The clays of the Motur group are often slightly ferruginous.

Motur-Barakar boundary.

The Motur-Barakar boundary-line is, on the whole, well defined. At several distant places, as Dolari and Kosmeri on the Tawa and below Sonada on the Bhoura stream, the contrast is very well marked between the hard white sandstones of the coal-measures and the softer earthy tinted rocks above. On the Tawa below its confluence with the Machna the distinction is not so marked. Some other parts of the boundary are only approximately accurate on account of the covered condition of the ground.

Barakar-Talchir boundary.

The base of the Barakar group is very vaguely definable as a strict geological horizon. The characters of the two deposits are not only blended vertically by interstratification, but it would appear as if this also occurred horizontally—beds of decided Barakar type in one place being represented by as decided Talchir rock elsewhere. Thus it may be that the line given is not truly equivalent in different parts of the field. This feature will be indicated in the descriptions of the different sections.

Four separate areas.

The physical features suggest the division of the area into four portions: on the east a great fault quite detaches the Dolári outcrops from those lower down the Tawa; the great Machna fault cuts off this second area from that traversed by the Súki, and this again is separated from the Sonada outcrops in the valley of the Bhoura by a steep ridge of indurated sandstone along a vein of quartz infiltration.

THE DOLÁRI AREA.

Motur beds.

In the Tawa under Dolári village there is the fullest section of characteristically Barakar rocks within this whole district. The steep narrow Lodadeo-Baramdeo ridge has a back-bone of vein quartz, and the sandstone is disguised beyond recognition. In the small stream close under the north base of the ridge, thick, soft sandstone and red and green clay have a northerly dip of 20°. It would seem, therefore, that the main part of the ridge must be formed of these Motur rocks. In the Tawa, to the north, these same rocks have a low south-westerly dip. Below the Kari stream, the dip is 3° to south on both banks of river for half a mile, and then turns up sharply to a south-easterly dip of 20°, lowering to 10° near the quartz vein which crosses the river obliquely to east-30°-south in the direction of Lodadeo. The same rocks, with a more easterly dip, appear below the quartz reef up to the trap dike which crosses the river to south-35°-west, immediately under the eastern village of Dolári. The dike does not disturb the strata, the same strong bed of mixed earthy sandstone appearing on its west side, where it rests directly on a bed of coal.

Coal-measures: upper beds.

The change of formations is thus lithologically as abrupt at this spot as it could be; but the parallelism of stratification is unbroken. The coal is only seen just under the sandstone, the rest of the outcrop being covered up; but there is room for a large seam. From beneath it there rises a strong bed of white felspathic sandstone. Immediately under this again coal is seen for a small thickness, the rest of the outcrop, full twenty yards wide, being concealed. Below this, for 130 yards, there is white sandstone; then again coal. The covered outcrop of this seam is 40 yards wide, in which some layers of dark shale can be traced under water, but there is room for much coal in the unseen portions. There is then 50 yards of sandstones, and below it 20 yards of covered outcrop with coal at top. This fourth seam is also underlaid by strong white sandstone. These 350 yards of section, with an average easterly dip of 12°, represent about 200 feet of strata, containing what may be four strong seams of coal. I saw nothing to suggest that any of the outcrops are due to repetition by faulting.

Middle beds.

There is a marked change in the character of the underlying measures. The thick rough white sandstones are replaced by sharply defined hard flaggy beds, very fine in texture and of dull greenish-yellow shades, more of the Talchir than the Barakar type of rock; but the alternating shales are copiously carbonaceous, and with some strings and thin beds of bright coal. There is more disturbance in these beds, the dip being sometimes as high as 30°, but in the same easterly direction. The thickness is about 100 to 150 feet.

Lower beds.

Below these thin measures there is still a descending section for over half a mile to where a run of quartz crosses the river from north to south. The only rocks seen in this reach are thick sandstones, in composition and texture mostly of the Barakar type, though some would pass as Talchir, especially the lowest bed adjoining the quartz vein. The intervening earthy beds are completely covered; I conjecture that they are of Talchir type, not carbonaceous. I have, however, coloured the whole as Barakar, not to complicate this small area with boundaries of doubtful nature and position, as undoubted coal-measures occur again close by. The thickness of these lower beds may be 600 to 700 feet.

The Phopás: section and fault.

The quartz vein just mentioned occurs on a broken anticlinal axis; the silica simply filling the many cracks in the fractured sandstone, some central ones being much stronger than the rest. The reverse dip is seen in the indurated rock forming the reef, below which there is a blank of some 300 yards to where sandstone appears in force in the left bank at the confluence with the Phopás. It is a typical Barakar sandstone, and dips south-westerly at 15°. This rock forms the left bank of the Tawa for a quarter of a mile. It becomes much crushed and silicified, and is finally cut out by a run of broken Talchir rock agglomerated by silica. Up the Phopás, there is an ascending section for some 200 yards, the upper beds having somewhat the aspect of Motur sandstone; and they abut at a moderate angle directly against the same crushed mass of Talchirs. There is clearly here a fault of very considerable throw. The ridge of crushed and indurated Talchir rock is about 40 yards wide; and immediately on its south-west side the boulder-clay is quite undisturbed.

The Lodadeo stream.

In the small stream running parallel to the Phopás under the Lodadeo ridge, and at 100 yards from the Tawa, there is a two-feet seam of bright coal, covered by strong sandstone and resting on thick carbonaceous shale. The dip is 23° to west-south-west. For more than a mile in a direct line typical Barakar rocks are exposed at intervals up this stream; the dip is very variable in amount and direction. The last outcrop, at west-6°-north from Lodadeo, is a white sandstone, dipping north-easterly at 15°; Talchir clay occurring close behind it at the same level. The fault here is unaccompanied by any crushing or vein rock.

The Doléri fault.

The above indicate all the outcrops in the Doléri area. The continuation of the measures along the south base of Lodadeo has not been followed out. In the stream north of Doléri, I fully expected to find the repetition of the main section in the Tawa, the ground between being quite flat, with nothing to suggest a great break in the rocks. At the nearest point, however, just to north of the village, typical Motur beds occur, having a low southerly inclination, and continue so to westwards. In proceeding down the westerly reach, there is a run of fracture with quartz veining; and the dip increases, through an ascending section of the same sandstones, to within 300 yards of the Tawa, where it is 30° to south-south-west. The actual rock against which these sandstones abut is not exposed in the banks of the stream; but a little below its confluence with the Tawa, there is a good section of one of the reefs of broken rock cemented by quartz infiltration, so frequent in this region. I believe the rock it includes to be Talchir; but owing to the small scale of the map, I have not complicated it by attempting to represent these small and obscure outcrops. Talchir clay is seen at several points with a low northerly dip on both banks throughout the Baspur reach of the Tawa. There can be no doubt of the presence of a great east-west fault, having a northern downthrow of several hundred feet, bounding the Doléri coal-field on the north. Two miles east of Doléri, at the angle of the stream south-east of Siwanpát, there is an outcrop of broken and silicified rock on the exact run of the Doléri fault. The whole country here north of the Tawa is deeply covered by soil.

Site for a boring.

A boring in the gully between the two villages of Doléri ought to cut all the coal within 250 feet from the surface.

THE MACHNA AREA.

The Golai reach.

The Doléri fault is well seen in the Tawa at the bend below Baspur. A mass of crushed Talchir rocks indurated by silicious infiltration projects into the river from the west. Close under it on the left bank, massive white Barakar sandstone is seen dipping at a moderate angle from the fault; but within a few yards it turns up to a low southerly inclination which lasts throughout this north-east reach of the river, and as far as a pair of strong trap dikes cutting very obliquely in a nearly east-west direction, across the Tawa, under Golai. The sandstones throughout this length are decided Barakar, and unless repeated by faulting (of which there is no appearance) they represent a thickness of 700 to 800 feet. The outcrop is very little interrupted, but no coal is seen; and such earthy beds as are exposed are only slightly carbonaceous, yet nearly the whole group must be here exposed.

The Silapti reach.

The two great trap dikes south of Golai about correspond with an anticlinal flexure. At the mouth of the Gonapur stream they are beautifully exposed, cutting sharply through a strong bed of fine pale greenish-yellow sandstone of decided Talchir character. It contains, however, small strings of bright coal; and the gray sandy clay under it, as seen up stream in the Tawa, is slightly carbonaceous. The low northerly dip of the sandstone is not in the least disturbed by the dikes, each about 20 yards wide. The sandstone is continuous down the left bank of the Tawa, gradually rising to the west and then to north, where the gray clay rises with it. Under this another strong bed of fine sandstone crops up in force, ending at a line of broken and crushed ground. As in the Doléri area, I have coloured these doubtful beds with the Barakar group. Beyond the crush, which may also include a small fault, a very typical Talchir rock appears, massive greenish-gray splintery clay with thin bands of hard compact limestone; it is overlaid by thick sandstone like the preceding. All have a low northerly inclination, soon becoming quite flat, and then turning up to the north. These beds are very well seen in the stream between Silapti and the Tawa, and threads of coaly matter are observable in the sandstone. They end along a marked line of fracture crossing the river to west-30°-north; some Barakar-like sandstone occurring immediately to the north of it, and then there is a blank of fifty yards in the section.

It would be impossible to follow closely the lines of this Silapti inlier to east or west, the ground is so flat and covered with clay. In the stream north-east of Golai only Barakar beds are seen, with some crops of very poor coal. The feature north of the Golai dikes is, on the whole, a blunt wedge of lower strata exhibiting two flat synclinal folds with intervening crush, elevated with faulting, and throwing off the coal-measures to the south and north.

The Temni reach.

To the north of the blank in which the last section ends, thin-bedded measures come in with carbonaceous shales and poor coal, probably representing the middle measures of the Doléri area. The dip is at first southerly, soon turning over in a flat anticlinal, and the northerly dip lasts up to the confluence with the Machna. The outcrops are nearly continuous throughout, strong sandstones of undecided character; the few earthy partings being also uncharacteristic, and but faintly carbonaceous. The whole are, however, Barakar. A thin seam of coal occurs under the great sheet of sandstone on the left bank, at the Temni ford. I saw nothing to suggest a concealed outcrop of strong coal.

The Mardánpur outcrops.

So far, in what might be called the main section through this Machna area, there is very small appearance of useful coal deposits. It was from outcrops in the Machna itself under Mardánpur that the large quantity of coal was taken which gave such satisfactory results in a trial on the Great Indian Peninsula Railway in 1873. From the confluence of the Machna and Tawa a great sheet of strong Barakar sandstone rises gently to westwards along the bed of the former stream. Under Douri a long deep pool has been cut by the water through this rock into an underlying earthy bed, which is quite concealed, the same mass of sandstone continuing above the pool and extending on the left bank up to where the river bends to the west-south-west. For a hundred yards or so near the bend the sandstones on the right bank have a considerable north-westerly dip; and in the bed of the river is visible the crack along which, by faulting, this abutting stratification takes place. There must also be a south-westerly or some equivalent line of fracture at the back of this upheaved mass of beds. It is at the top of this little section that the coal seams occur, cutting very obliquely across the river bed. At every available point of the outcrop, along a length of some sixty yards, coal was cut on both sides of the river. The holes are now filled in, and little can be seen. There are two seams, the lower one apparently with a strong parting of shale. There did not seem to be in either seam room for more than four to five feet of coal. The dip is 30°. At a short distance up stream the dip changes to north-east, and continues so up the next, north-south, reach. I could not find that the seams are repeated on the reverse outcrop. There is thus here an oblique synclinal flexure, sloping towards the main fault, and the continuity of the coal at this spot is therefore closely limited. The place seems, on the whole, very unpropitious for mining operations.

The Kotmi section.

The next north-westerly sweep takes the river for about half a mile across the main fault into most typical Talchir rocks, the massive fine clay with thin bands of dense, nearly black, limestone. Above this there are again Barakar beds, showing an east-west flat synclinal, south of which a very massive bed of sandstone rises to the next bend of the river. Beneath this rock, along the east-west reach, a band of flaggy sandstones and coaly shales is very well exposed, and the same are traceable for some distance up the gully draining from across the fault to the west. All have a moderate northerly dip, and at the head of the island, at the southerly bend of the river, they are regularly underlaid by the fine Talchir sandstone. These flaggy measures may correspond with those already noticed twice on the Tawa.

The Talchirs on the Machna.

Hitherto we have only seen broken sections between the Barakars and the Talchirs. In the Machna the sequence is quite continuous; and if the conjecture regarding the identity of the flaggy coal-measures here and at Doléri be correct, the contrast between the underlying beds in the two sections is striking: at Doléri the Barakar type of sandstone prevails, while in the Machna, from below the flaggy coaly beds a mile north of Shápur, we meet only rocks of Talchir character. There is another feature in these beds on the Machna different from what is found to the west—the sandstones are in force down to a low horizon in the series, alternating with the boulder clay and even containing large erratic blocks itself. From the Machna the section was followed to the south boundary up the stream flowing near the high road. The moderate northerly dip is remarkably steady throughout, and unless there are repetitions by faulting the thickness would be over 2,000 feet. From the top of the section there are broad intervals between the successive crops of thick fine sandstone. The clays which no doubt occur in these spaces being quite concealed, an important aid was missed in fixing a fair boundary for the groups; the presence of carbonaceous matter was thus also not ascertainable. I did not hit upon the clay with limestone which is peculiar to the Talchirs, though not confined to a particular horizon. The boundary I have given is certainly higher than that taken elsewhere. Locally it is the best marked line in the series, and for coal-searching purposes the most suitable. I had not time to work the question out more minutely.

The Machna Fault.

The Machna fault is quite as well marked as those in the Doléri area, and has nearly as great a throw. The upland to the north-west of it is almost entirely formed of Talchir clay, except the hills north-west and north of Shápur, which are mostly sandstone, perhaps partly Barakar. The Barakars occupy the low ground along the river. The run of the fault is very steady; the bulge appearing in it on the map may be due to incorrect plotting of the river course. At both points where it cuts the Machna there is much confusion of the stratification, with infiltration of silica; but at the only point where I got a view of the actual plane of contact, the feature is very sharply defined. This occurs in a small gully, within fifty yards of the river at the north-westerly elbow above the Murdánpur coal crops. The exact line is not traceable in the covered ground north of Douri, nor can it be fixed on the Tawa. It has probably died out in that direction, as all these features are clearly connected with the special disturbance of the stratification along the margin of the basin. To the south-west the fault is seen at the base of the range of gneissic rocks at the mouth of the Amdhana gorge. Its continuation up the valley has not been followed out.

Site for a boring.

For reasons already indicated, I should not advise any outlay upon an attempt to mine the seams in the detached block of measures south of Murdánpur. If there is any continuity in the measures, the seams should be found in a favorable position away from the fault-ground. A good site for a boring would be on the left bank of the Tawa, a little below the confluence of the Machna. A depth of 400 feet here would probably prove the whole of the measures.

THE SUKI AREA.

Kosmeri.

The east end of this portion of the field, about Bhumkadhána and Kosmeri, is hopelessly concealed and obscure. From isolated outcrops and the frequent occurrence of vein quartz, it is plain that the stratification is much disturbed. On the left bank of the Tawa at Kosmeri there is typical Barakar sandstone, and on the right bank as typical Motur rock. At a few feet from the base of this latter group there is all along this portion of the boundary an extensive exhibition of trap rock, appearing generally as a sheet-dike along the outcrop of a massive bed of rusty clay.* This character is well displayed in the Lohár river, where there is a wide spread of the sandstone covering the trap at a low angle, and broken and altered by it.

The Súki section.

In the Súki itself there is an unbroken section, including apparently the whole Barakar group; and if it is so, the promise of coal is very poor indeed, there being no seam of workable thickness or quality. At the very mouth of the river the strong white Barakar sandstone is in force; typical Motur beds appearing a little to north of it on the left bank of the Tawa; all with a steady northerly dip. At top of an irregular earthy parting in this band of massive sandstone, there are three inches of platy coal. Up stream, in a short west-south-west reach, under the top sandstone there is a flat section of very irregular flaggy sandstone showing already some Talchir characters. Above this there is a long north-south reach with no strong crop, but on right bank the section is almost continuous; a low northerly dip in soft sandstone and sandy micaceous shale. Two of these beds are carbonaceous, with mere strings of coaly matter, the associated sandstone being persistently fine, earthy, greenish. From the upper end of this reach to the causeway at the road-crossing there are continuous crops of strong fine sandstone with a few thick irregular partings of sandy micaceous shale, faintly carbonaceous in strings. The flat reach above the road is along the top of a lower band of softer, finer sandstones, below which the Talchir clays come in with scarcely any associated sandstones. In this section the characters of the two groups are run together in a very puzzling manner: the Talchir-Barakar sandstones are clubbed in force with interspersed carbonaceous matter. The boundary adopted is a very marked one, but manifestly on a lower horizon than that taken on the Machna. If the section on the Machna were to be interpreted by the analogy of that on the Súki, the base of the Barakars should be taken well to the south of Shápur.

Doubtful prospect of coal here.

The question of coal in this locality turns upon whether the shales observed become coal to the deep, and whether some of the top measures may not be suppressed by faulting. I noticed no direct evidence for the latter supposition: there is no doubt much quartz-veining along the boundary at this spot, but I do not think it is connected with faulting; such is rarely and indirectly the case with the many runs of vein-quartz observed throughout the district. The conformable succession of strata here seems unbroken. There is also little encouragement to adopt the other supposition. I would rather connect the want of coal here with the other peculiarities noticed in the original characters of this formation in this position.

West of the Súki.

In the left bank of the Tawa, on the strike of the ridge of indurated rocks separating the Bhoura and Súki streams, there is an excellent section of the bottom Motur beds. There are two strong bands of mottled sandy clays overlaid by thick sandstones. These latter pass up to form the crest of the ridge along the quartz vein. The extension of the Barakars along the base of this steep ridge is quite covered up by débris.

THE SONÁDA AREA.

The north boundary.

The point at which the Motur-Barakar boundary crosses the ridge of induration is put in inferentially, from the apparent structure, the rocks of the ridge being too much disguised for close identification. The position of the boundary on the Bhoura Nadi is well defined. In the reach to south-east of Bandábir the massive greenish-brown and mottled purple clays of the Motur are in force. A lower band of the same appears near the bend of the river to east-by-south of Sonáda. To the west, along the flanks of Jámgarh, these bands, if present, are concealed by talus. But I rather think they die out to the rise: the sandstone forming the east flanks of the hill are seen to pass down into the low ground to the north; at the high level they are porous and conglomeritic, while low down they become earthy and fine grained.

The coal-measures.

The Barakar beds are fairly exposed for several miles along the Bhoura stream, the course of which is very oblique to the strike of the formations. For this reason and the doubtful accuracy of the map, it is impossible to be certain whether two or more of the outcrops may not belong to the same seam, or to assign an approximate thickness for this group. It is certain, however, that the coal-measure characters are more pronounced than on the Súki. The top rock is as usual a very strong white sandstone. Under Sonáda, near the top of the long west-by-north reach of the river, two poor strings of coal occur in local partings of this rock. Above Sonáda there is a succession of south-westerly reaches, across the measures, and west-north-westerly reaches more or less along the strike. At the northerly elbows between the four first pairs of these reaches coal is seen on the left bank under strong sandstone. The first two are, I think, the same seam, and also the third and fourth, at a lower horizon. From one to two feet of coal is seen in each case; but there is room for more in the concealed part of the outcrop. There are besides several bands of covered ground in these sections that may contain coal. To the west the whole group passes into the base of the Jámgarh range, and is obliquely overlapped by the covering trap which passes across it to rest on the Talchirs west of Teter. The first scarp north of Teter is of coarse Barakar sandstone, locally altered by the overlying basalt.

The Talchirs.

Here again we find an instance of the mutual accommodation that occurs between these two groups: as the Barakar type of sandstone, and with it true coal deposits, increases, the Talchir stamp of sandstone decreases. I have still left a considerable band of these latter within the coal-measures boundary, so as to let it correspond with the continuous line in the Súki area; taking as top of the Talchirs the first appearance of the massive, fine, silicious clays with thin bands of hard compact limestone north of Kupa. Beneath this there are still some strong beds of the fine yellowish sandstone. The very massive Talchir clay is deeply weathered out in the broken ridge south of Teter, showing the quartz vein passing vertically through it. Lower still the boulder deposits are splendidly exposed in the eastern scarp of the Kota plateau.

Site for boring.

The high road (it only deserves the title from the causeways and culverts constructed across the watercourses) passes through the Súki area, which, as has been shown, offers the least promise of coal. For any really effective roadway from the north, Sonáda is much the nearest and most accessible point of the coal-measures. There is no serious obstruction to overcome between it and Dhár on the present road. For this reason it is here that a first attempt should be made to prove the ground for a workable coal, although the apparent prospect of success may be less promising than in the Machna or Dolári area. In choosing an actual site for boring one might at first be inclined to avoid the visibly barren ground at the top of the measures at the bend of the river just above the village. Yet, as none of the outcrops are very tempting, the object should be to test the whole measures a little to the deep of the outcrop. With this in view I should take up a position immediately to the north of Sonáda village. When there is such uncertainty as to the thickness of the measures it is difficult to assign a depth for a boring. If 400 feet at Sonáda did not clear all the measures, the remainder could be tested by another shallow boring half a mile to the south.

TRAP.

The few trap dikes that occur are not likely to prove very troublesome. The only one seen in the Sonáda area is close to the Talchir boundary. There are none in or near the Súki section. None is seen either in the Machna. A ten-yard dike stops just short of its left bank, at the mouth of the little stream south-south-west of Douri. It is very remarkable for its finely developed prismoidal structure. Two small dikes cut across the Tawa, just below the mouth of the Machna. A boring here might be placed between the two, or below the lower one. Several fine dikes cross the Tawa within this area to south. In the Dolári area a strong dike crosses the river immediately above the outcrop of the coal seams.

The general habit of the trap dikes is to coincide approximately with the lines of flexure, and therefore with the local strike of the strata. The great dike at Kámti and that north of the Tawa at Kosmeri cut across the strike and parallel to the Machna fault. There are some good instances in this field of the tendency of intrusive trap to run out in sheets at the contact of thick clay bands with strong overlying sandstone. The broad run of trap along the north bank of the Tawa in the Kosmeri reach is a good case of this, as already mentioned. There is also a very good example of it in the Talchirs on the Phopás: a band of hard sandstone is seen broken or tossed about upon an underflow of trap. I am disposed to think that the cotemporaneous trap said to occur in the Talchirs elsewhere is only an exhibition of this phenomenon.

I have seen nothing to disturb the opinion I have already expressed that all the trap in these formations is of the age of the Deccan rock. There is excellent evidence within the range of our map of the advanced denudation of these formations at the time of its outflow. The trap forming the summit of Jámgarh is fully 800 feet thick, the top scarp of Motur rocks having an elevation of about 2,000 feet. At a distance of little over two miles, in the gorge west of Teter, the trap is at the lowest level. The fact of there being no infratrappean deposits in such a position only shows that even then this must have been an upland gorge. There is one mode of occurrence of the trap that suggests at first sight an opposite conclusion regarding the periods of denudation. The best case in point I noticed this season, about twelve miles to the east-north-east of Dolári: a very strong dike, traced for several miles along the low ground, cuts straight up the west face of Kilandeo hill and forms a ridge on the summit. It is certain that when this occurred the whole of the present low ground was filled with rock; but it is quite open to supposition that the filling rock was in great part trap. The unquestionable fact, that the main Narbada valley itself, formed on the south by scarps of Mahadeva strata, is re-excavated out of the covering trap-formation—the floor of the valley being still of this rock at many places in front of the Mahadeva scarp—removes any apparent improbability in such a conjecture as that here made regarding the inner vallies of the basin and the pretrappean denudation of the Mahadeva formation. A just estimate of this feature is an important factor in our judgment upon the time-relations of the Mahadeva series, the top member of which is the Jabalpur (Rajmahal) group, in comparison with the Bagh series (cretaceous) in this region; and also upon the distinction of the Deccan and Rajmahal trappean formations.

QUARTZ-VEINS AND FAULTS.

Quartz-veins: composition.

The frequent occurrence of strong and continuous quartz-veins is perhaps the most peculiar feature of the southern zone of this rock-basin. Along the northern margin, where the contortion of the strata is locally greater than here, I have not observed a single case of quartz-veining; and in other basins of these formations the thing is almost unknown. There is, however, one marked feature of these veins that has long been familiar to us in many parts of India in metamorphic and transition rocks—a peculiar pseudomorphic structure, thin shining plates of pearly white quartz, either in parallel arrangement or confusedly entangled, with empty interstices. I do not recollect noticing this form in vein-stones of other countries; but in India it seems to be nearly universal. The fine lines on these shining plates have suggested that they may be after micaceous iron. Stains of iron are common, but there are no signs of any other metal in these veins. There is often associated brecciated quartz.

Not fault-rock.

The whole rock was for long currently designated amongst us as 'fault-rock.' In highly contorted and altered strata, where this stone was most familiarly known, it is generally difficult to establish the fact of faulting; but in these little disturbed and unaltered deposits the evidence is often complete. From many observations made in this field I can say that this rock seems rather to shun a connection with faults, as if they were related to opposite results of disturbing action—such as if faults occurred along lines of maximum compression and these veins along lines of tension. The vein forming the core of the ridge between the Súki and Bhoura streams is at least eight miles long, varying from one foot wide in the Talchir clays to six feet in the sandstones. In the masive unstratified clays vertical dislocation might not be detected, but there is little or no sign of crushing or rubbing alongside the vein, clear sections of which are abundantly exposed in the broken ridge south of Teter. In the sandstone it is quite surprising how this fissuring of the rock and introduction of foreign matter does not even locally derange the moderate dip of the bed: an indurated shell of sandstone of variable width commonly adheres to the south face of the vein, to the rise of the dip; and in this, as well as in the strips of rock enclosed by the ramifications of the veinstone, the low northerly dip is uniformly undisturbed. The best defined and most continuous of the quartz-runs correspond with this description. The few cases where the quartz appears locally near the Dolári and Machna faults might be quoted on the other side; but besides that these spots are quite local as compared with the length of those faults, it can generally be seen, as in the Tawa and the Phopás, that the quartz is located in broken flexures adjoining the fault, where no vertical displacement has occurred, and does not represent what is properly designated by the term fault-rock; it is simply veinstone. One of the veins which have given rise to the group of sandstone ridges north-west of Shápur is seen on the path descending the Amdhána gorge to the south to run continuously into the gneiss as a comb-vein one foot wide.

The structure of some of these runs of vein quartz is peculiar: the small veins of which the reef is made up are not always coincident with the general direction. In the hill north-west of Bhoura the component veins are nearly normal to the direction of the aggregate. In the Tawa above Temni the run of the quartz rib is east-west, while the veins composing it lie north-east, south-west. It is perhaps conceivable that 'colliding' earthquake waves might shatter the rock in this manner.

Peculiar local structure.

The induration and metamorphism of the sandstone that occurs in connection with this infusion of quartz is sometimes remarkable, as it takes the form of felspathisation, the development of innate crystalline felspar. I noticed this at the contact of the Lodadeo reef in the Tawa. It is important to find it in this connection, because the most marked case I found of this form of induration is not visibly connected with any veining. It is in the small hills on the Bhoura stream south-west of Bandábir. They are formed of sandstone having quite a granite-like hardness; the porosity of the sandstone is not destroyed, nor is the earthy matrix quite obliterated; but bright glassy facets of a felspar are disseminated, manifestly innate; and it must hold the whole in an invisible bond to account for the peculiar hardness of the rock.

Peculiar induration.

The well-marked faults within the stratified series form another peculiar feature of this region. We are familiar enough with the word 'fault' in the northern region, about Mohpani; but they would be correctly termed slips in comparison with the principal faults in the Shápur field, where top Barakars or even high Motur strata are brought into contact with middle or lower Talchirs; in which cases the throw must be from 500 to 1,000 feet.

Faults: dimensions.

Notwithstanding the dimensions of these faults, I cannot look upon them as anything but local features, not merely in the literal and obvious sense, but as connected with and determined by pre-existing local conditions. The Machna, north-east-south-west, fault runs with the crystalline range of Bhaorgarh; but I cannot regard them as concomitant effects of elevating action. I rather connect the fault with a pre-existing feature of the basin of deposition, of which there seems to be coincident evidence in the marked change in the character of the Talchir strata along that line.

Local relations.

The only noteworthy instance in India of Barakar deposits occurring at a high elevation is on the continuation of these outcrops to the east, in the Pench valley. The case has been appealed to as a sufficient refutation of the general remark that the areas of Barakar deposition correspond in a recognisable manner with the existing depressions of the peninsula. The objection, however, will not hold if it is shown that the apparent exception is due to local elevation; and there seems every probability that such was the case. But for the great faults which set on to the eastward from Shápur, the coal-measures here would correspond in position with those in the Pench. The fault which brings up the coal on the Pench river west of Chendia has, on the contrary, its upthrow to the north: here, too, the quartz veins keep clear of the faults.

Different throw in east and west.

The structural features of this region offer a most tempting subject for study. I believe it will appear that the limitation of the sedimentary basin here is not in any important degree due to elevation from the south; but rather that this present local stratigraphy is connected immediately with pre-existing surface features.

SUMMARY.

Although the foregoing details are reduced to the minimum required for any one who would carry on the investigations described, or even as evidence for any one who would study the questions discussed, each of which is marginally noted, it may be well briefly to point out what conclusions or opinions have been arrived at.

As to coal: the only tangible and immediate prospect is, of course, where we are certain of the coal-measures; I think there is a good prospect of coal in the Shápur field; if not in the Sonáda area, then further east, on the Tawa.

Regarding those places where we are searching for the measures themselves, I can only say that there is a reasonable hope of finding them. In the central area, where the deep borings are being made, the chief risk is that the measures are out of reach. In the trials along the border of the basin the extra hope is that the measures, if there, have partaken in the extension and rise of the Talchir beds towards the northern outcrop; the extra risk, that the boring may be outside the overlap.

The prospect held out of coal on the lower Narbada is in some ways more precarious, the ground being so very far from any known occurrence of the coal-measures; yet the countervailing suggestion of a probable original expansion of the measures towards the sea-board is not without weight; and the presence of a rock that is known to overlie most of the important coal-basins in India is no small encouragement. Considering the importance of a local supply in Western India, the chance ought not to be left untried.

NOTE ON COALS RECENTLY FOUND NEAR MOFLONG, KHASI HILLS, *by* F. R. MALLET, ESQ., *Geological Survey of India.*

On the 19th April 1875, I visited the coal recently discovered near Umsaomát and at Dédúm Hill.

Two spots were pointed out to me near Umsaomát, one about half a mile, and the other a mile south-east of the village. The coal at both these places is worthless, being shaly, and the seams only a foot thick.

The following assays have been made of the Dédúm coal, and for comparison of that at Máobeláka, the latter seam is that which for some time past has been worked for the supply of Shillong with fuel:—

	Dédúm Hill.	Máobeláka.
Hygroscopic water	6·0	3·4
Volatile matter, exclusive of water	24·6	39·6
Fixed carbon	37·8	55·2
Ash	31·6	1·8
	100·0	100·0

The Máobeláka coal was taken from the fresh working face of the quarry, while that from Dédúm was from the surface of the weathered outcrop. The latter coal would probably be found considerably better a few feet in. The seam is three feet thick (the Máobeláka coal being 3′ 6″ to 4′ 0″), but the outcrop is at the foot of a perpendicular sandstone cliff 15 feet high, from the top of which the hill slopes back steeply for 30 or 40 feet more. The hill near the top of which the seam is situated appears to be equally steep all along the southern side, so that the coal could not be quarried. If sufficiently good in the interior, however, and no better seams should be found in the neighbourhood, it might be worth mining on a small scale, as when the projected new road is completed, the facilities for carriage from Dédum to Shillong will be considerably greater than those from Máobeláka. The roof is good and the seam horizontal, and a few miners could raise sufficient coal to supply Shillong. The chief difficulty in the way of opening such a mine under native supervision would be the risk of explosions if it were not properly ventilated.

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DURING APRIL, MAY AND JUNE.

Laterite from Pigeon Island. Limestone from Bittrapar one of the Laccadives, and Rock specimens from the Vingorla rocks. Presented by A. O. HUME, ESQ., *Secretary to Government of India.*

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Bibliothèque Universelle et Revue Suisse, Vol. LII, Nos. 205—207, (1875), 8vo., Lausanne.

Bibliothèque Universelle et Revue Suisse. Archives des Sciences Physiques et Naturelles, Vol. LI, No. 204, & LII, Nos. 205 & 206, (1875), 8vo., Geneva.

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Geological Magazine, New Series, Decade II, Vol. II, Nos. 3—5, (1875), 8vo., London.

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